Regional Extinction Risk and Conservation Priorities for Persian Gulf Marine Bony Fishes

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REGIONAL EXTINCTION RISK AND CONSERVATION PRIORITIES FOR PERSIAN GULF MARINE BONY FISHES

by

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B.S. May 2012, Old Dominion University

A Thesis Submitted to the Faculty of Old Dominion University in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE

BIOLOGY

OLD DOMINION UNIVERSITY
August 2016

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ABSTRACT

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Old Dominion University, 2016
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Around the world, protected areas are the primary conservation measure used to combat biodiversity loss; however, these are often established without comprehensive species-specific information, leading to placement in areas that often do not address the processes that threaten biodiversity. To address this, International Union for Conservation of Nature Red List assessments are being utilized to determine species-specific threats and population status at the global and sub-global levels. This study examines the regional extinction risk for all known marine bony fishes of the Persian Gulf. About 8.3% of the 471 marine bony fishes assessed are at elevated risk of regional extinction. The distribution of threatened species is primarily linked to coastal areas with high human activity and environmental extremes. Evaluation of the Persian Gulf marine protected area network identified limited coverage, with most marine bony fishes having 5% or less of their ranges covered. Given this limited coverage, the offshore islands of Saudi Arabia and near-shore areas around Abu Dhabi and the Kuwait/Iraq border, which contain high concentrations of endemic and threatened species as well as critically important habitats, are recommended for future conservation prioritization. With efficient and effective management and protection, there is potential for the status of the threatened species to improve within this globally important region.

This thesis is dedicated to my family (Rod, Connie, Emily, Saralyn, Carson and Chloe), all of whom provided me with much needed support and encouragement throughout my graduate degree.

ACKNOWLEDGMENTS

There are a number of people without whom this research would not have been possible. First, I would like to thank my advisor, Dr. Kent Carpenter, for his guidance and support throughout my time in this program. I also thank my committee members, Dr. Heather Harwell and Dr. Holly Gaff, each of whom provided essential advice and contributions to this research. Thanks to Dr. Gina Ralph, who was instrumental throughout much of my degree.

Thanks to all who were involved with the regional IUCN Red List assessment workshops in Doha, Qatar, including the regional and international experts who attended these workshops: H. Abdulhalim, M. Abdullah, E. Abdulqader, M. Alam, A. Al-Atteya, Q. Alghawzi, A. Al-Binali, N. Al-Hashmi, M. Al-Husaini, K. Al-Jaber, K. Al-Khalaf, J. Al-Khayat, A. Al-Khulaifi, A. Al-Kuwari, S. Al-Kuwari, G. Allen, M. Al-Mukhtar, H. Al-Nazry, F. Bilal, J. Bishop, J. Burt, K. Carpenter, H. Choat, B. Collette, I. El-Mabrouk, D. Feary, S. Hartmann, Y. Iwatsuki, F. Kaymaram, F. Krupp, H. Larson, F. Mansour, K. Matsuura, S. May, H. Motomura, T. Munroe, B. Russell, W. Smith-Vaniz, and J. Williams. Also, thanks to G. Khiami, for his support with workshop logistics; M. Comeros-Raynal, C. Linardich, B. Polidoro, and G. Ralph for workshop facilitation; A. Shirmohammadi, E. Shores, and D. Slater for species data collection; L. Chao, M. Craig, H. Larson, R. Pollom, G. Ralph, and Y. Sadovy for reviewing draft species assessments, and C. Pollock for the preparation of the assessments for publication on the Red List. I also thank the Qatar National Research Fund (a member of The Qatar Foundation). Without its financial support, this research would not have been possible.

Finally, I thank my fellow lab and classmates: B. Stockwell, M. Semcheski, C. Klepac, H. Hancock, C. Linardich, A. Ackiss, E. Biesack, M. Harvey, and M. Comeros-Raynal. Without your friendships, I would have gone completely insane over these last four years!

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INTRODUCTION

In recent decades, biodiversity has increasingly been recognized as a global asset with enormous value to humanity (Cardinale et al., 2012). However, threats to biodiversity are continually expanding, resulting in species extinction rates exceeding normal background rates by two to three orders of magnitude (Pimm et al., 2014, 1995). In response to this global crisis, the 193 Parties to the Convention for Biological Diversity (CBD) agreed to significantly reduce the current rate of biodiversity loss (UNEP, 2002) and called for the protection of at least 10% of each of the world's ecological regions by 2010 (CBD, 2006a). Unfortunately, these targets were not achieved, and, in 2010, the CBD adopted a strategic plan for biodiversity based on the 20 Aichi Biodiversity Targets. Target 11 calls for the expansion of the global protected area system to at least 17% of the terrestrial and inland water areas and 10% of coastal and marine areas by 2020 (CBD, 2010). Recent estimates of the coverage of the global network of protected areas indicate progress, with an increase in coverage of approximately 3.1% in the terrestrial environment and 2.3% in the marine environment (Butchart et al., 2015; Chape et al., 2003). Despite these efforts, the rate of biodiversity loss has not significantly been reduced to date (Butchart et al., 2010).

While protected areas are not the only solution for biodiversity conservation, they are the cornerstones on which protection strategies are built (Margules and Pressey, 2000). Therefore, it is essential that protected areas safeguard all elements of biodiversity from processes that act as threats to their existence in the wild (Margules and Pressey, 2000). The effectiveness of protected areas in fulfilling this task depends on the extent to which two objectives, representativeness and persistence, are met. Representativeness is a long-established goal referring to the need for protected areas to represent the full variety of biodiversity, ideally at all

The journal model for this thesis is Biological Conservation levels of organization (Austin and Margules, 1986; Margules and Pressey, 2000). Persistence refers to protected areas that, once established, promote the long-term survival of the species and other elements of biodiversity they contain by maintaining natural processes and viable populations and by excluding threats (Margules and Pressey, 2000; Soulé, 1987). However, because protected areas slow or stop the extraction of natural resources, or in some cases, compete with economically profitable businesses (e.g., residential/commercial development), they are often located in remote or unproductive areas (Margules and Pressey, 2000), and the effectiveness of such decisions on biodiversity is rarely assessed (although see Araújo et al., 2007).

As the number and extent of protected areas continue to expand, evaluation of the existing protected areas is imperative to inform conservation measures. A gap analysis identifies inadequately represented features (e.g., species or habitats) within protected areas through spatial overlay of multiple data sets, including species distributions, habitat layers, and protected area records (D'Amen et al., 2013; Mazaris et al., 2014; Scott et al., 1993). With outputs based on specific conservation measures, such as percent of area or species covered, gap analyses effectively identify unprotected areas of high biodiversity value (Langhammer et al., 2007; Margules and Pressey, 2000; Mazaris et al., 2014; Possingham et al., 2006; Rodrigues et al., 2004a), which can be considered future conservation priorities. However, the quality of gap analyses are dependent on the accuracy and resolution of their underlying spatial data, which are generally scarce and of low resolution, leading to two types of errors: commission and omission (Kujala et al., 2011; Rodrigues et al., 2004a; Scott et al., 1993; Visconti et al., 2013). A commission error is when a species is considered covered by one or more protected area(s) when, in fact, it is not, while an omission error is when a species is considered not covered, but in fact, it is (Rodrigues et al., 2004a). Thus, to be effective, gap analyses require comprehensive species-specific information to minimize these errors and protect the area and species most in need. However, comprehensive species-specific information is often unavailable because it either does not exist or it is difficult to collate (Polidoro et al., 2012).

The International Union for Conservation of Nature (IUCN) Red List is the global standard for evaluating the conservation status of species (Mace et al., 2008), and categorizes species according to symptoms of high extinction risk using comprehensive species-specific information. This information can be utilized in global or sub-global multi-taxa analyses of species biodiversity, patterns of threat (Carpenter et al., 2008; Dulvy et al., 2014; Malak et al., 2011; Nieto et al., 2015; Polidoro et al., 2012) and protected area coverage and representativeness (D'Amen et al., 2013; Rodrigues et al., 2004b; Venter et al., 2014). However, the coverage of marine species on the Red List has been limited. In an effort to address this gap and develop a baseline for the conservation status of marine species, the Global Marine Species Assessment (GMSA) project, a joint initiative of the IUCN Species Survival Commission and Conservation International, was formed in 2005 to assess the extinction risk of 20,000 marine species. Prior to 2015, nearly 13,500 marine species had been assessed at the regional and/or global level primarily through the action of the GMSA. These assessments are driving conservation efforts at both the species and site levels, resulting in direct benefits to marine biodiversity and the people relying on it.

An area of particular concern is the Persian Gulf; although officially recognized as such by the United Nations, it is also referred to as the Arabian Gulf by Arab countries and hereafter referred to as 'the Gulf'. Marine biodiversity and habitat quality are declining rapidly in the Gulf from elevated sea surface temperatures (SST) and increased anthropogenic activity (Burt et al., 2014). The Gulf, defined as the semi-enclosed basin connected to the Gulf of Oman through the Straits of Hormuz (Sheppard et al., 1992), is characterized by some of the world's most extreme environmental conditions, including salinity values often exceeding 45 ppt, as well as annual SST variation of over 25°C, 12°C in the winter to summer highs exceeding 36°C (Coles, 2003; Reynolds, 1993). Anthropogenic activities, such as coastal development (Van Lavieren et al., 2011), overharvesting of fishing stocks (Grandcourt, 2012), oil and gas exploration and production (Carpenter et al., 1997b), and insufficient management, regulation, and enforcement of related policies (Sheppard, 2016), are also negatively affecting marine biodiversity in the region. However, to develop strategies to mitigate the impacts of these deleterious activities and conditions, it is vital to understand their nature and scope (Grandcourt, 2007a). Although global Red List assessments have been completed for all known species of reef-building corals, mangroves, seagrasses, seabirds, marine mammals, sharks, rays, and groupers that occur in the Gulf (Carpenter et al., 2008; Polidoro et al., 2010, 2009; Short et al., 2011), a critical data gap remained for a majority of the Gulf marine bony fishes.

To address this gap, the present study assessed the complete marine bony fish assemblage in the Gulf against the regional IUCN Red List categories and criteria. The information gained from this study will provide a complete understanding of the threats and population status to these species, and drive species and site-specific conservation efforts in the region. Thus, the objectives of this study were to: 1) identify the full diversity of marine bony fishes (focusing only on the Infraclass Teleostei) within the Gulf, 2) evaluate the conservation status of these fishes using the IUCN Red List categories and criteria, 3) identify species and areas of high conservation priority, 4) evaluate the coverage of Gulf protected areas in terms of these fishes and the critical habitats, and 5) provide recommendations for future conservation priorities.

MATERIALS AND METHODS

IUCN RED LIST PROCESS

The IUCN Red List categories comprise nine levels: Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), and Not Evaluated (NE). These categories are objectively assigned based on criteria that indicate symptoms of extinction risk, e.g., rate of population decline (Criterion A), geographic range size and decline (Criterion B), population size (Criteria C and D), or quantitative analyses (Criterion E) (Böhm et al., 2013; IUCN, 2012a; Mace et al., 2008). Species are considered EX when there is no reasonable doubt that the last individual of the taxon has died. A species qualifies for EW when there is no reasonable doubt that it is extinct in its natural habitat (Subcommittee, 2014). Species qualify for one of the 'threatened' categories (e.g., CR, EN, or VU) if the best available evidence indicates that they meet the thresholds and conditions for that category in one of the five criteria (IUCN, 2012a). A species is listed as NT when it is close to qualifying for or is likely to qualify for a threatened category in the near future. Species are assigned to the LC category when they do not qualify for a threatened category or NT. A species qualifies for DD if there is inadequate information to apply any of the five criteria (i.e., species with taxonomic uncertainty, little biological information or insufficient data to quantify the impact of known threats). Lastly, a species that has not yet been evaluated against the five criteria is assigned to the NE category.

While the Red List was originally developed for use at the global scale, growing interest in conservation status at sub-global scales led to the creation of the Guidelines for Application of IUCN Red List Criteria at Regional and National Levels (IUCN, 2012b). A species' regional or national conservation status is assessed utilizing the same nine categories, and two additional categories: Regionally Extinct (RE) and Not Applicable (NA). A species qualifies for RE if there is no reasonable doubt that the species is extinct within the region of interest, but exists elsewhere in the wild. A species qualifies for NA if it is unsuitable for inclusion in the regional Red List (e.g., introduced species). Regional and national assessments also consider the potential effects of immigration from (and emigration to the) outside of the region of interest on the sub-global population.

Following the regional IUCN Red List methodology (IUCN, 2012b), species assessments for the native marine bony fishes of the Gulf were conducted with extensive input from scientific experts, including representatives from all Gulf States. A total of 471 species were assessed at two workshops held in Doha, Qatar in 2013 and 2014. Before each assessment workshop, information obtained from primary literature was compiled regarding each species' taxonomy, distribution, population trends, ecology, life history, threats, and conservation measures. Regional and international experts reviewed each species account, provided additional unpublished data, and were consulted after the workshops if further information was needed, but unavailable at the time of the assessment. Based on the best available data, experts assigned each species to a regional IUCN Red List category (IUCN, 2012a; Subcommittee, 2014). Following the assessment workshops, each species account was reviewed by at least two evaluators to ensure data quality and consistency. The species accounts were submitted to the IUCN Red List Unit for a final consistency check prior to publication on the publicly accessible IUCN Red List of Threatened Species website (http://www.iucnredlist.org), which occurred in November 2015.

SPECIES MAPPING AND ANALYSES

Prior to the assessment workshops, generalized polygonal distribution maps were created in ArcMap 10.2 by connecting known and inferred occurrences (based on expert opinion and extrapolation from surrounding areas) for each species (ESRI, 2014). These distribution maps were then reviewed and updated by experts as needed during each workshop. Species distributions were limited to the study system. The Musandam Peninsula and Straits of Hormuz that border the entrance to the Indian Ocean were excluded from this assessment as the coral and fish assemblages found in these areas are not representative of the diversity and abundance of coral and fish assemblages present within the Gulf (Burt et al., 2011; Feary et al., 2010).

To prioritize site-based conservation and research efforts in the Gulf, species richness analyses were conducted for the Gulf marine bony fishes. Species' distribution maps were clipped to one of four National Geophysical Data Center's ETOPO1 one arc-minute global relief model (Amante and Eakins, 2009) bathymetry layers (0-25, 0-50, 0-75, 0-100 m), depending on their known depth range. These clipped distributions were converted to a 1 km by 1 km raster grid; this resolution was chosen because spatial information was not gained with a finer resolution (e.g., 500 m^2), but a coarser resolution (e.g., 5 km^2) resulted in the loss of spatial information. Species richness per cell was then calculated by counting the number of overlapping species distributions at each 1-km^2 cell location. These analyses were completed for all marine bony fishes, with the exception of 15 species that do not have confirmed ranges within the Gulf (Table SI). Species richness analyses were also conducted for specific subsets of species, including the endemic, threatened, and DD species. All spatial analyses were performed in a world cylindrical equal area projection.

In a separate analysis, the spatial distribution of coral-dependent fishes was examined (Buchanan et al., 2016). For these species, the generalized distributions were modified based on the coral-assemblage habitat data from United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) (UNEP-WCMC et al., 2010). Prior to analyses, coral assemblages around several offshore islands of Saudi Arabia (Jana, Jurayd, and Harqus) and Kuwait (Kubbar), which were missing from the original UNEP-WCMC coral assemblage data, were added based on descriptions and localities from the published literature (e.g., Basson et al., 1977; Carpenter et al., 1997a).

Protected Area Overlap

Gap analysis was utilized to determine if the existing Gulf protected area network covers all marine bony fishes and critical habitat types (coral reefs, mangroves, and seagrasses). Ecologically, these habitats are considered critical because they are either highly productive, diverse, or serve as essential feeding, breeding, or nursery grounds for particular species (Carpenter et al., 1997b). Review of primary literature and input from experts determined that over 200 of the Gulf marine bony fishes are associated with at least one of these habitats during part or throughout their ontogeny. Gaps in representation were identified by overlaying the distributions of all marine bony fishes, critical habitat types and protected areas in ArcMap 10.2 (ESRI, 2014)(Fig. 1). The percent area overlap of each species' geographical range and habitat type with existing protected area boundaries was then calculated. Although previous studies have set species-specific representation targets, e.g., 100% representation within protected areas for limited-ranging species (D'Amen et al., 2013; Rodrigues et al., 2004a), there are few defined conservation guidelines for species representation needs (Klein et al., 2015). Thus, a species was considered a "gap" species if its range did not overlap with any protected area, "partially covered" if < 100% of its range was found within protected areas, and "covered" if 100% of its range was found within any protected areas.

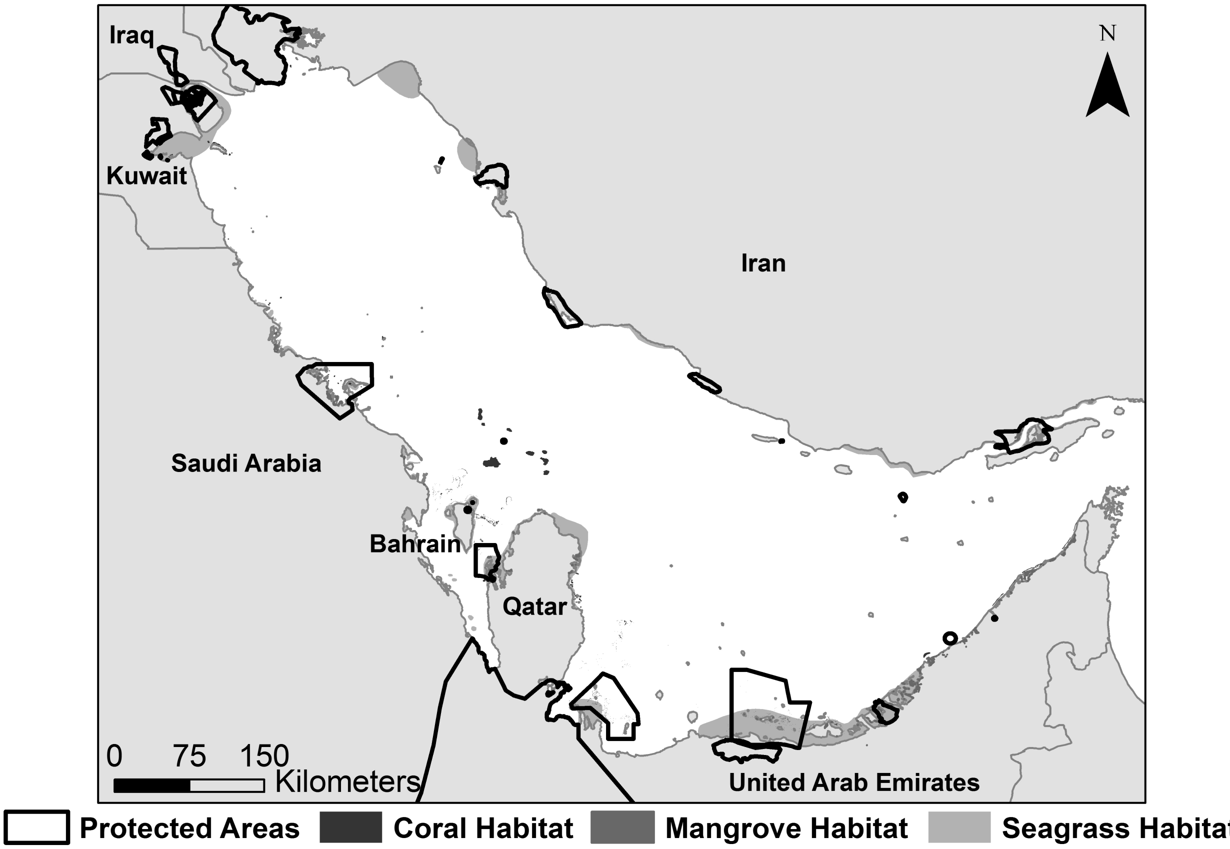


FIG. 1. Map of the coral, mangrove, and seagrass habitats in the Gulf. All nationally, designated protected areas utilized for GAP analysis are also displayed. For visualization purposes, a 1-km buffer was placed around mangrove habitat. Data Sources: Giri et al., 2011; IUCN and UNEP-WCMC, 2015; UNEP-WCMC and Short, 2005; UNEP-WCMC et al., 2010.

Habitat data were obtained from the UNEP-WCMC (Giri et al., 2011; IUCN and UNEP-WCMC, 2015; UNEP-WCMC and Short, 2005; UNEP-WCMC et al., 2010). The primary source for Gulf protected area polygon and point data was the November 2015 version of the World Database of Protected Areas (WDPA) (IUCN and UNEP-WCMC, 2015). Following the methodology of previous analyses of protected area coverage (e.g., Coad et al., 2013; Jenkins and Joppa, 2009; Rodrigues et al., 2004b; Visconti et al., 2013), only protected areas that were nationally designated were included in analyses (Table SII). In total, 30 nationally designated protected areas were identified for the Gulf. The actual protected area polygon provided by the WDPA was used in the analyses for 21 of the 30 protected areas. However, for nine protected areas, only a point (representing the centroid of the protected area) and the estimated area covered were provided to the WDPA. These protected areas account for about 42% (~2,890 km^2) of the total protected marine area in the Gulf (~6,810 km^2), thus, exclusion of these protected areas from the analyses would have substatially underestimated the total protected area coverage in the Gulf. Boundary information was found for two of these protected areas, Jubail Marine Wildlife Sanctuary (Krupp and Khushaim, 1996) and Hawar Islands (King, 2002), and was used to create their polygons. For the remaining seven protected areas with point data, a circular buffer was created around the point provided equal to the estimated area of each protected area. To prevent overestimation of protected area coverage from overlapping records, all records were merged into a single layer.

Examination of Fish Community Structure

The fish community structure within the most speciose areas of each Gulf State's Exclusive Economic Zone (EEZ) was examined to determine if the effectiveness of a protected area, in terms of protecting high species diversity, varies by location in the Gulf. Highlighting areas where protected areas would provide similar, more or less benefit to species diversity in the Gulf States can inform the placement of protected areas. All areas with the top 5% of marine bony fish diversity (358-379 species km^{-2}), which were identified in the species richness analysis of all marine bony fishes, within each Gulf State's EEZ were exported as separate shapefiles. Using the random point tool in ArcMap 10.2, three sites were generated a priori within these hotspots (ESRI, 2014)(Fig. 2). A species list for each site was then generated using the "Selection by Location" tool with a search distance of 1 km, such that all species within a 1-km radius of a site were considered present, while those that were not, were considered absent (ESRI, 2014). The presence/absence data for all marine bony fishes at each site were then entered into a resemblance matrix. A hierarchical agglomerative cluster analysis was performed on the S8 Sorensen resemblance matrix and principle component analysis (PCA) was utilized to identify the structure of the data. Fish community structure groups identified by PCA were overlain on a two-dimensional MDS ordination of the same distance matrix for visualization of community structure. In addition, PCA identified the species driving the differences among these groups. All multivariate analyses were performed in Primer-E v6 software (Clarke and Gorley, 2006).

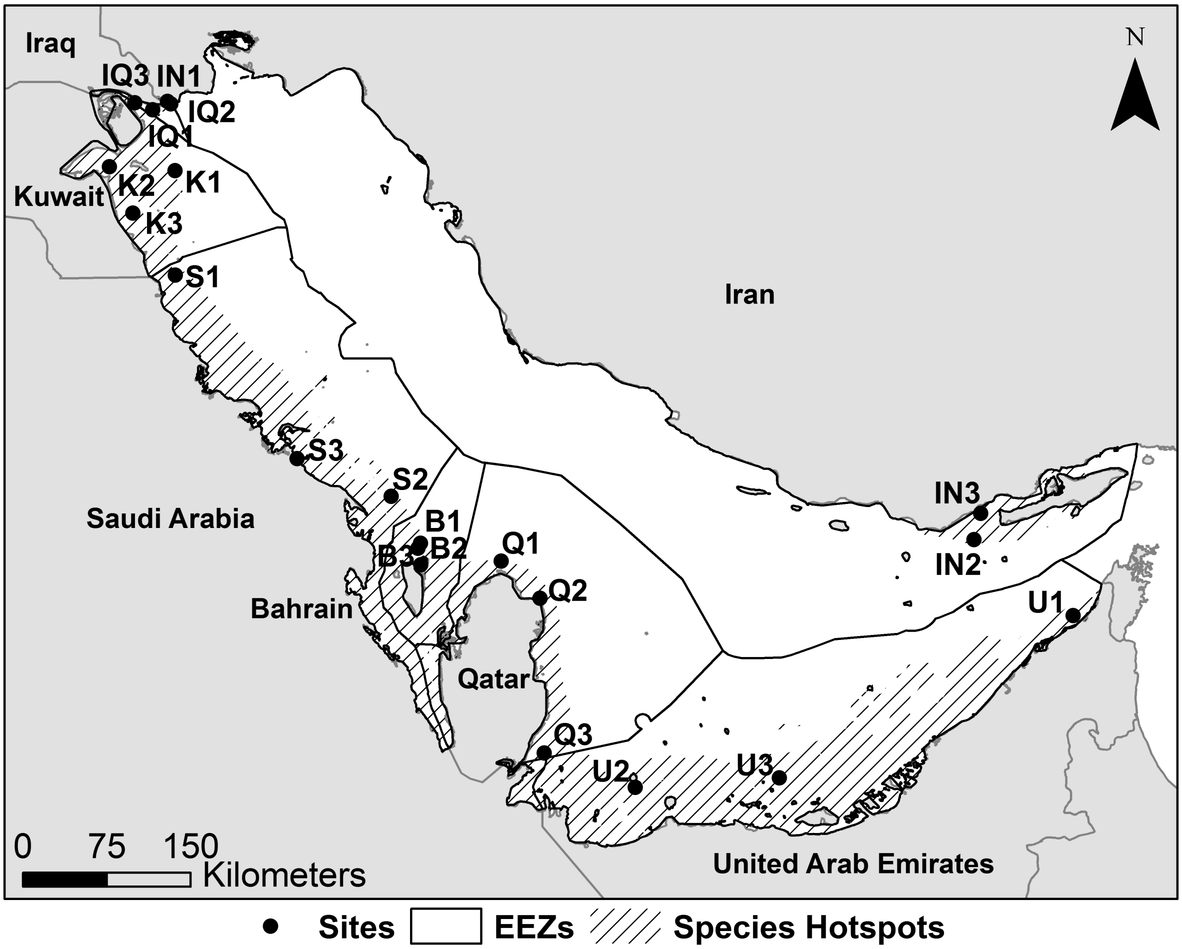


FIG. 2. Map of species hotspots (diagonal lines) within each Gulf State's EEZ (solid lines). Symbols indicate a priori randomly selected sample sites utilized in analyses of fish community structure.

RESULTS AND DISCUSSION

CONSERVATION STATUS OF MARINE BONY FISHES

Of the 471 marine bony fishes regionally assessed in the Gulf, 20% (96 species) are listed as DD, 71% (334 species) as LC, 2% (10 species) as NT, 5% (23 species) as VU, and 2% (8 species) as EN (Fig. 3). However, the proportion of threatened species is uncertain given the number of DD species. Following IUCN Red List methodology (Hoffmann et al., 2010; IUCN, 2011; Schipper et al., 2008), the best estimate for the proportion of threatened species in the Gulf is 8.3%; it may be as low as 6.6%, if all DD species are not threatened, or as high as 27%, if all DD species are threatened (Table 1).

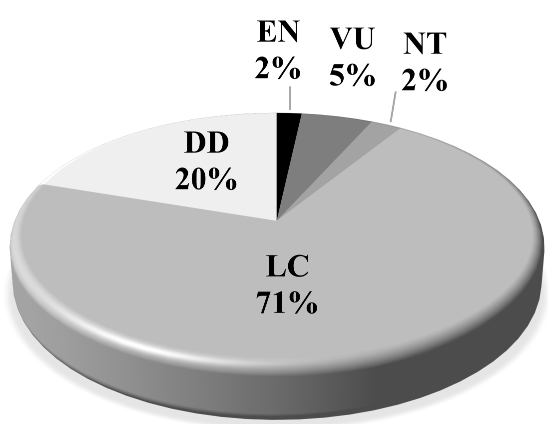


FIG. 3. IUCN Red List status of marine bony fishes in the Gulf. Red List category abbreviations are EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern and DD = Data Deficient.

Table 1. Proportion of threatened marine bony fishes in the Gulf.

Estimate	% Threat
Lower Bound (CR+EN+VU)/(Assessed-EX)	6.6%
Mid-point (CR+EN+VU)/(Assessed-EX-DD)	8.3%
Upper Bound (CR+EN+VU+DD)/(Assessed-EX)	27%

Six species are listed as threatened under criterion A because of fisheries pressures leading to population declines (Table 2). Of these species, *Eleutheronema tetradactylum* is listed under A4 of this criterion, while the remaining are listed under A2. For example, Hamoor, the Orangespotted Grouper (*Epinephelus coioides*), has been assessed as VU under this criterion (Choat et al., 2015). This long-lived (22 years) species is the most important reef-associated commercial species in the Gulf and has undergone extensive declines over the past 27 years due to fisheries exploitation. Stock assessments in the Gulf indicate Hamoor is either fully (Qatar, Abdullah et al., 2010) or overexploited by as much as six times the sustainable limit (Abu Dhabi, Grandcourt, 2012; Grandcourt et al., 2005). Hamoor is also a minor component of commercial fisheries bycatch throughout the Gulf. For this species, and other threatened species impacted by fisheries, there is a need for improved monitoring of its population status to prevent further decline of its regional stock.

Table 2. Regional Red List assessments of marine bony fishes threatened at the Gulf level, including the criteria and primary vulnerability or threat that resulted in their threatened status. Also included is each species' current Global Red List Status (EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern, NE = Not Evaluated).

Family	Species	Global Red List Assessment	Gulf Red List Assessment	Gulf Red List Criteria	Vulnerability or Threat
Mugilidae	*Liza klunzingeri*	NE	VU	A2bd	Fisheries
Acanthuridae	*Acanthurus sohal*	LC	VU	B2ab(i,ii,iii)	Coral dependent
Acanthuridae	*Zebrasoma xanthurum*	LC	VU	B2ab(i,ii,iii)	Coral dependent
Blenniidae	*Alticus kirkii*	LC	VU	D2	Restricted range
Blenniidae	*Omobranchus mekranensis*	VU	VU	D2	Restricted range
Caesionidae	*Caesio lunaris*	NE	VU	B2ab(i,ii,iii)	Coral associated
Caesionidae	*Caesio varilineata*	NE	VU	B2ab(i,ii,iii)	Coral associated
Chaetodontidae	*Chaetodon melapterus*	LC	VU	B2ab(i,ii,iii)	Coral dependent
Chaetodontidae	*Chaetodon nigropunctatus*	LC	VU	B2ab(i,ii,iii)	Coral dependent
Chaetodontidae	*Heniochus acuminatus*	LC	VU	B2ab(i,ii,iii)	Coral dependent
Epinephelidae	*Epinephelus coioides*	NT	VU	A2d	Fisheries
Gobiidae	*Gobiodon reticulatus*	NE	VU	B2ab(i,ii,iii)	Coral dependent
Gobiidae	*Gobiodon citrinus*	NE	EN	B2ab(i,ii,iii)	Coral dependent
Labridae	*Chlorurus sordidus*	LC	VU	B2ab(i,ii,iii)	Coral dependent
Labridae	*Halichoeres marginatus*	LC	VU	B2ab(i,ii,iii)	Coral dependent
Labridae	*Scarus ferrugineus*	LC	VU	B2ab(i,ii,iii)	Coral dependent
Labridae	*Scarus ghobban*	LC	EN	B2ab(i,ii,iii)	Coral dependent
Labridae	*Scarus persicus*	LC	VU	B2ab(i,ii,iii)	Coral dependent
Polynemidae	*Eleutheronema tetradactylum*	NE	EN	A4d	Fisheries
Pomacentridae	*Abudefduf vaigiensis*	NE	VU	B2ab(i,ii,iii)	Coral dependent
Pomacentridae	*Amphiprion clarkii*	NE	EN	B2ab(i,ii,iii)	Coral dependent
Pomacentridae	*Chromis flavaxilla*	NE	VU	B2ab(i,ii,iii)	Coral dependent
Pomacentridae	*Chromis xanthopterygia*	NE	EN	B2ab(i,ii,iii)	Coral dependent
Pomacentridae	*Dascyllus trimaculatus*	NE	VU	B2ab(i,ii,iii)	Coral dependent
Pomacentridae	*Neopomacentrus cyanomos*	NE	VU	B2ab(i,ii,iii)	Coral dependent
Pomacentridae	*Pomacentrus aquilus*	NE	EN	B2ab(i,ii,iii)	Coral dependent
Pomacentridae	*Pomacentrus leptus*	NE	EN	B2ab(i,ii,iii)	Coral dependent
Pomacentridae	*Pomacentrus trichourus*	NE	EN	B2ab(i,ii,iii)	Coral dependent
Sciaenidae	*Otolithes ruber*	NE	VU	A2ad	Fisheries
Scombridae	*Scomberomorus commerson*	NT	VU	A2ad	Fisheries
Stromateidae	*Pampus argenteus*	NE	VU	A2d	Fisheries

Twenty-three species are listed as threatened under criterion B because of their strong associations with coral assemblages, which have a total area of ~700 km^2 in the Gulf (Table 2). Of these, 21 are coral-dependent fishes, which are directly dependent on live coral for survival because of their functional relationship with live coral as corallivores, obligate coral dwellers, and/or coral recruiters (Buchanan et al., 2016). For example, the Citron Goby (*Gobiodon citrinus*), an obligate coral dweller that utilizes live coral for shelter throughout its ontogeny, has been assessed as EN because of its restricted range (about 35 km^2), its severely fragmented population, and the continuing decline in the area and quality of coral-assemblage habitat due to climate change and coastal development (Larson et al., 2015). The two remaining threatened species listed under criterion B are *Caesio lunaris* and *C. varilineata*, which are also strongly associated with, but not dependent on, coral assemblages throughout the Gulf (Carpenter et al., 2015a, 2015b). For these species, protection of coral assemblage habitat using marine protected areas (MPAs), in particular, at the offshore coral assemblages would be of great benefit. In addition, restoration of lost coral habitats and development and implementation of coastal development practices that facilitate resilience-based management are needed (Feary et al., 2013; Sale et al., 2011).

Two species (*Alticus kirkii* and *Omobranchus mekranensis*) are listed as VU under criterion D because they are known from less than five locations and there is a potential for a serious plausible threat in the near future that may lead to extinction in the Gulf (Table 2). For example, the Leaping Blenny, *A. kirkii*, is known from only a few locations in the Gulf, where it inhabits the intertidal zone of exposed, rocky shores. Within the restricted range of this species, there is a high prevalence of coastal development, particularly in the Hormozgan province, which could lead to the extirpation of this species (Williams et al., 2015). Thus, impact assessments of coastal development activities in areas where this species occurs should be conducted to evaluate their effects on it. In addition, monitoring of this species' population throughout the entire development process is recommended.

Of the 31 threatened Gulf species, 13 are at a higher risk of extinction regionally compared to their global assessment (Table 2). For example, the Narrow-barred Spanish Mackerel (*Scomberomorus commerson*) is assessed as NT globally, but is listed as VU in the Gulf. This species is heavily exploited throughout the Gulf, with an estimated 32% decline in landings over the last 20 years (Collette et al., 2015). In addition, its highly migratory nature creates difficulties for developing localized management strategies. Thus, a region-wide management plan is suggested instead of single littoral state initiatives.

Ten species are close to meeting the thresholds and conditions for listing as threatened and are thus assessed as NT (Fig. 3). All are important commercially exploited species that are experiencing population declines because of fisheries pressures and/or habitat loss. For example, stocks of the Malabar Blood Snapper (*Lutjanus malabaricus*) have declined severely in Kuwait and Abu Dhabi but it is locally common in fish markets in other parts of the Gulf. Without changes to regional management, the population decline is expected to continue, and it will likely become threatened in the near future (Iwatsuki et al., 2015).

The vast majority of marine bony fishes (334 species) in the Gulf are listed as LC (Fig. 3). These species are generally characterized as wide-ranging and abundant. While many of these species are exploited by artisanal and commercial fisheries in parts of the Gulf or face other threats (e.g., coastal development, habitat degradation), the populations are not declining at rates that are likely to lead to extinction in the near future. For example, the Golden Trevally (*Gnathanodon speciosus*) is a valuable commercial species in the Gulf. It is very common in markets throughout the Gulf, and is also caught as bycatch in shrimp and trap fisheries. This species is considered to be fully exploited off Qatar (Abdullah et al., 2010) and overexploited in the southern Gulf (Grandcourt et al., 2004). However, population declines over the last three generations do not meet the thresholds required for placement in a threatened category, resulting in its listing of LC (Smith-Vaniz et al., 2015). Despite this, the stock of this species should be monitored to ensure that it is harvested sustainably into the future.

Ninety-six species are assessed as DD (Fig. 3). A number of these species are known only from a few localities (e.g., *Taenioides kentalleni*) or are easily missed during visual surveys because of their small size and/or cryptic nature (e.g., *Bryaninops amplus*). For some species, their presence within the Gulf needs confirmation (e.g., *Callionymus sagitta*, *Kyphosus bigibbus*). Also, an increase in taxonomic work in the Gulf has resulted in recent descriptions of new species (e.g., *Acanthopagrus randalli*, Iwatsuki and Carpenter, 2009), for which there is little information available. With increased taxonomic, habitat, fisheries, and population information, these species could qualify for a threatened category. Therefore, increased research on these species is imperative to determine their current level of extinction risk.

Of the 471 species that occur in the Gulf, 15 (3%) are considered to be endemic (Table SIII). Of these, eight species (53%) are assessed as LC, and are characterized by widespread distributions and high abundances (e.g., *Ilisha compressa*). The remaining endemic species are assessed as DD because they were either recently described or have undergone taxonomic revisions (e.g., *Upeneus randalli*, Uiblein and Heemstra, 2011) or were known from only a few records (e.g., *Taenioides kentalleni*). Like the non-endemic DD species, additional research is necessary to clarify their distribution, population status and trends, and threats, especially for the restricted ranging endemics.

SPATIAL TRENDS IN BIODIVERSITY OF MARINE BONY FISHES

In general, marine bony fish diversity is higher in the western and southern Gulf than along the northeastern coast (Fig. 4). Species diversity is also generally higher in near-shore areas, decreasing with distance from the coast. In contrast, however, the southeastern coast of Iran, around Qeshm Island, and several offshore Islands, including Failaka, Kubbar, Qaro, Umm Al-Maradem, Harqus, Fars, Karan, Al-Arabiya, Kurayn, Jana, and Jurayd, exhibit high diversity. Diversity also decreases towards the northern and southern parts of the Gulf. These patterns are driven at least in part by sampling effort. Extensively studied areas, such as Kuwait, Saudi Arabia, and the United Arab Emirates, consistently showed higher diversity, while lesser-studied areas, including several offshore islands (e.g., Harqus, Al-Arabiya, Fars islands) and the Iranian coast, consistently showed lower diversity. However, Al-Arabiya is known to have the most diverse coral-associated fish assemblages of all the Gulf islands (F. Krupp pers. obs.) and the Iranian coast is thought to have some of the most developed coral assemblages (Rezai et al., 2004; Sheppard et al., 1992). Unfortunately, many of these areas are not easily accessible to scientists and have yet to be thoroughly surveyed. Although increased research in these areas might provide more information about species' distributions, because they are poorly studied, the distribution information in our maps reflect the current understanding of bony fish diversity throughout the Gulf.

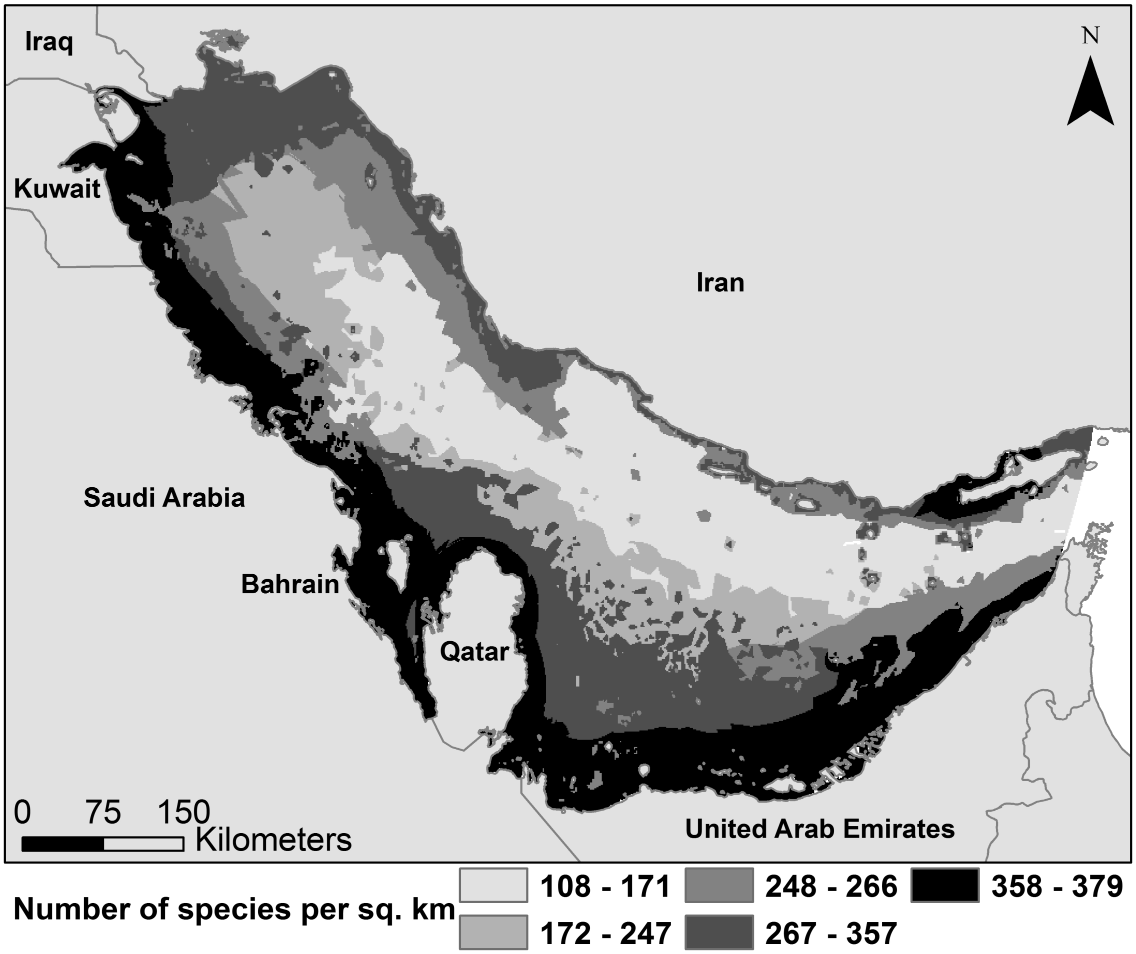


FIG. 4. Species richness of all marine bony fishes in the Gulf.

In terms of threatened marine bony fishes, high concentrations are found in near-shore areas from Kuwait to Bahrain and the United Arab Emirates (Fig. 5a). Higher percentages of threatened species are largely found in Kuwait, Saudi Arabia, and in areas of the United Arab Emirates (Fig. 5b). A higher number of threatened species near the coasts can be explained by their close proximity to the human population and the overall shallow depth of the habitats found in these areas. Close proximity to the coast subjects these species to direct and indirect anthropogenic activities such as coastal development and habitat fragmentation (Al-Ghadban and

Price, 2002). In shallower waters, these species are more likely to experience extreme temperature fluctuations that can lead to the degradation of near-shore habitats (Burt et al., 2014; Krupp et al., 2006). Hotspots of threatened species also occur at several offshore areas in Kuwait, Saudi Arabia, Bahrain, and the United Arab Emirates. These areas are highly diverse and contain complex coral assemblages, which many of the coral-dependent fishes utilize (Buchanan et al., 2016).

(a)

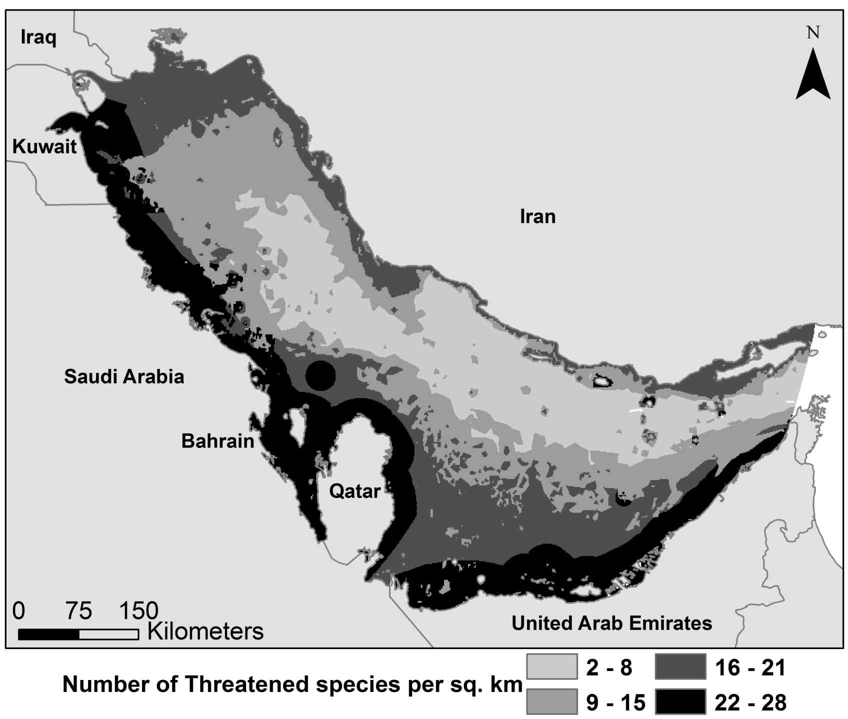


FIG. 5. Species richness of (a) all and (b) percent threatened marine bony fishes in the Gulf.

(b)

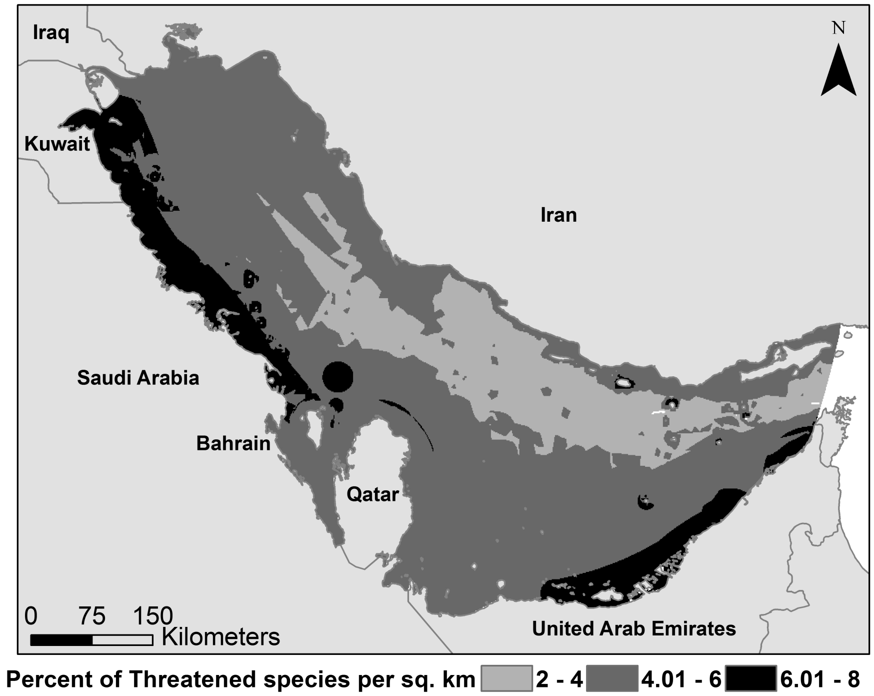


FIG. 5. Continued.

Similar geographic trends in species richness were also observed for the DD, coral dependents, and endemic marine bony fishes (Fig. 6-8), which are likely due to the general widespread nature of species' distributions in the Gulf. For the most part, a species is either present and found throughout the Gulf (e.g., > 300 species) or absent – though there are some exceptions to this (e.g., *Bryaninops amplus*).

In general, the patterns of DD species richness follows closely the trends of overall species richness, with higher diversity found in near-shore areas, decreasing with distance from the coast (Fig. 6a). However, unlike overall species richness, high numbers of DD species occur in the near-shore areas of Iran, which further enforces the need for more research in these areas. The high number of DD species in the coastal areas of the Gulf, where the impacts of anthropogenic activities and climate change are most severe (Al-Ghadban and Price, 2002; Burt, 2014; Burt et al., 2014) is of concern, as these species may be vulnerable to these impacts; however, insufficient data were unable to capture this possibility.

Based on the percentages of DD species, additional areas were highlighted, which are largely in offshore areas of Saudi Arabia and Iran (Fig. 6b). The hotspots off Saudi Arabia can be explained by several species, for example, Innerspotted Sandgoby (*Fusigobius inframaculatus*) and Fan Shrimp-goby (*Tomiyamichthys latruncularius*), which are currently only known from these areas. However, the offshore hotspots in Iran highlight areas with overall lower diversity and poor sampling, leading to the higher percentages of DD species.

(a)

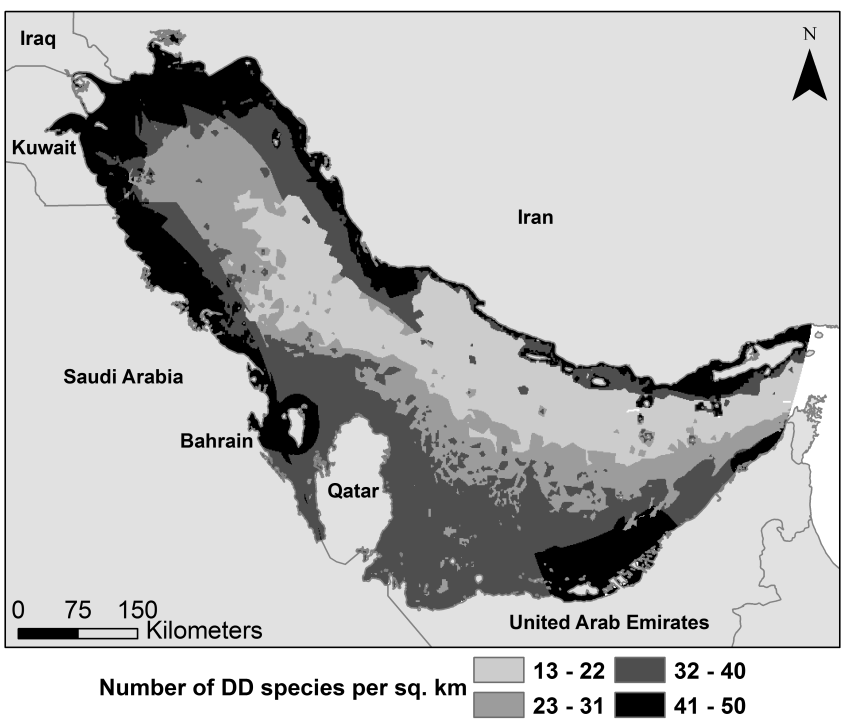


FIG. 6. Species richness of (a) all and (b) percent DD marine bony fishes in the Gulf.

(b)

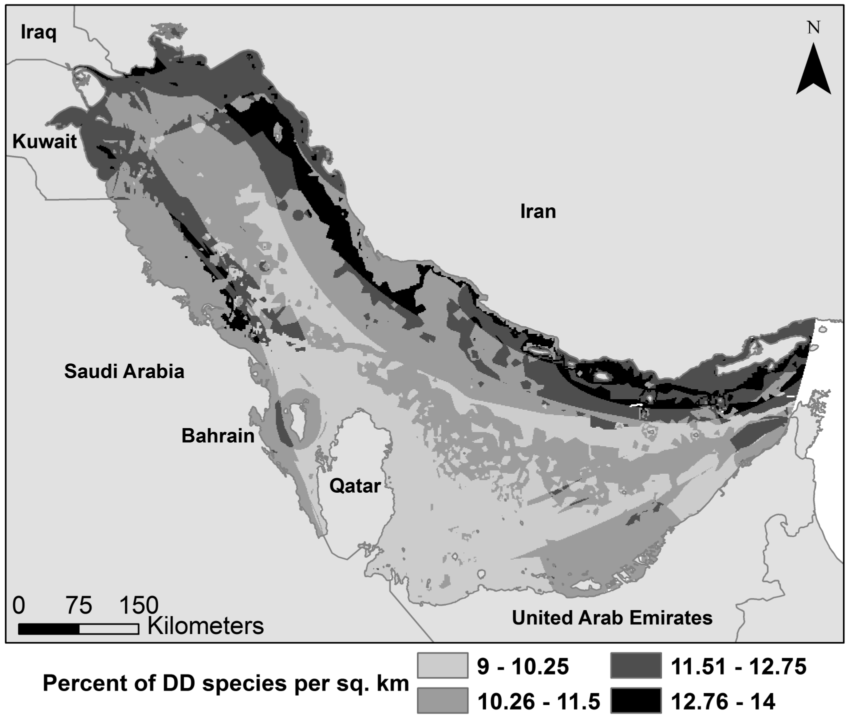


FIG. 6. Continued.

Coral-dependent species diversity was higher in the northern and southern Gulf, with a decrease towards the central and eastern Gulf (Fig. 7a). Species diversity was highest at the near-shore coral assemblages in central Saudi Arabia (near Abu Ali) and in the United Arab Emirates (near Abu Dhabi and Ras Al-Khaimah), and at the offshore islands of Kuwait (Failaka, Kubbar, Qaro, and Umm Al-Maradem) and Saudi Arabia (Al-Arabiya, Harqus, Jana, Jurayd, Karan, and Kurayn). The greatest number of threatened coral-dependent species occur in the northern Gulf, off Kuwait and Saudi Arabia, and in the southern Gulf, off parts of the United Arab Emirates, with a decrease towards the central and eastern parts of the Gulf (Fig. 7b). There was also a decreasing trend in threatened species from near-shore to offshore areas, with the exception of the Iranian coast. However, Buchanan et al. (2016) suggested that this pattern might be attributed to the poorly studied areas in the eastern Gulf, which likely also affects the distributions of all marine bony fishes in the Gulf.

(a)

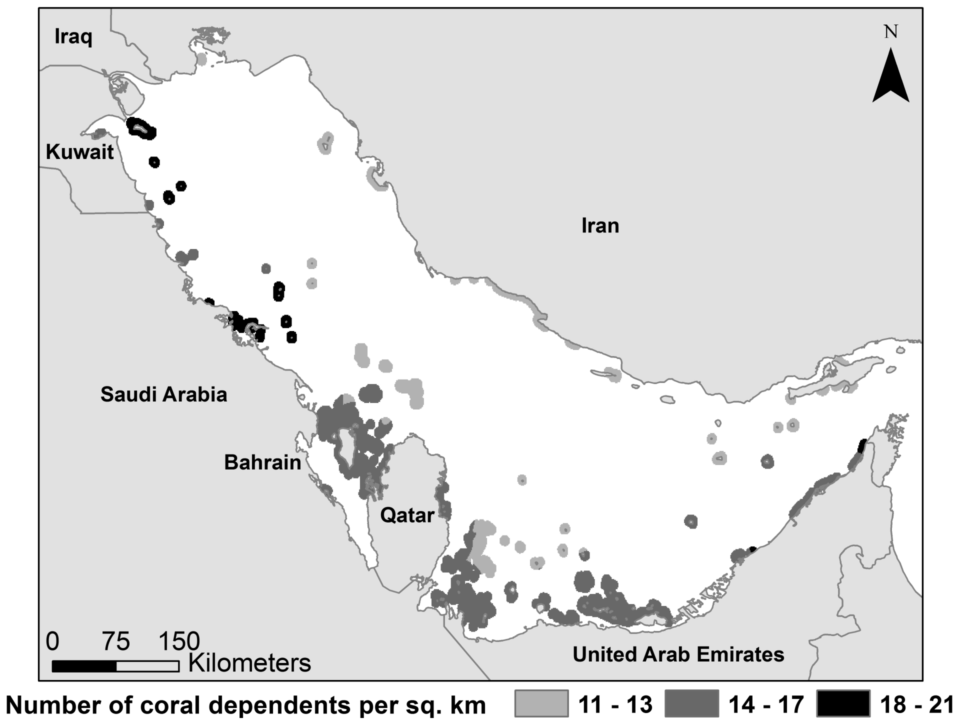


FIG. 7. Species richness of (a) all and (b) threatened coral-dependent bony fishes in the Gulf. Adapted from Buchanan et al., (2016).

(b)

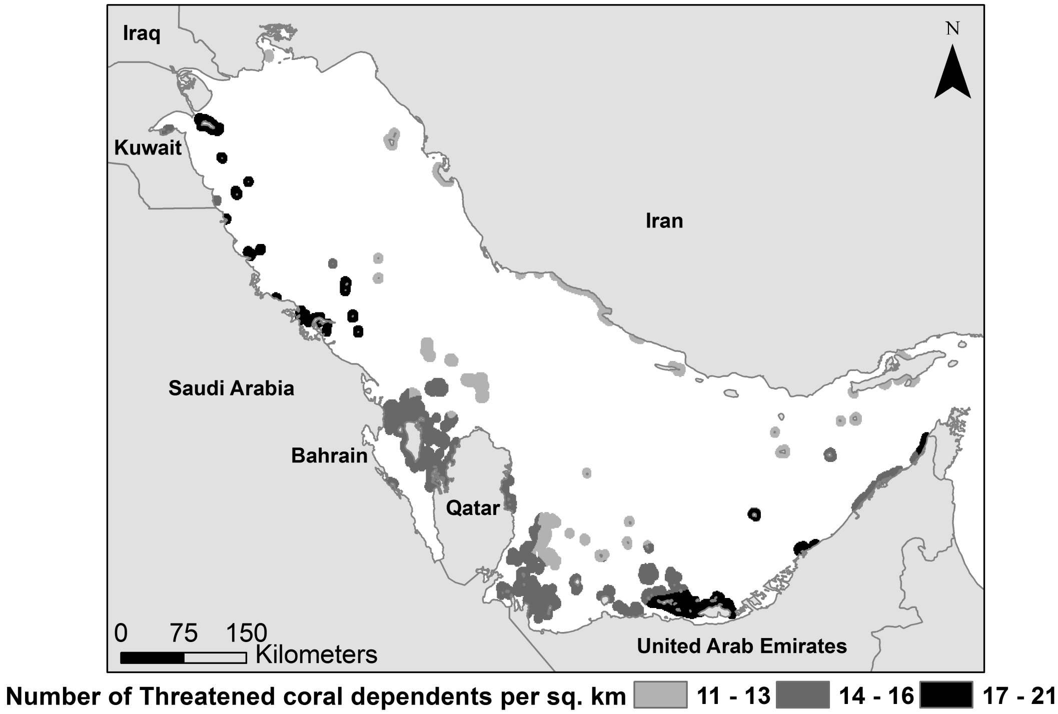


FIG. 7. Continued.

In general, endemic marine bony fishes are found at greatest concentrations from Kuwait to the United Arab Emirates, decreasing towards the central part of the Gulf (Fig. 8). Overall, endemism is quite low in the region as compared to nearby areas such as the Gulf of Oman and the Red Sea (Randall, 1995). Low endemism – and the overall lack of diversity – in the Gulf can be attributed to its youth (Randall, 1995) and its extreme environmental conditions (Coles and Tarr, 1990). Geologically speaking, the Gulf is quite young, only becoming a body of water following the last ice age (Randall, 1995). Thus, species within the Gulf are comprised mainly of re-colonized Indo-Pacific fauna (Carpenter et al., 1997b). In addition, the environmental extremes of the Gulf may act as physiological barriers, especially for larval stages, which may have more restricted thermal tolerance (Burt et al., 2011; Coles and Tarr, 1990).

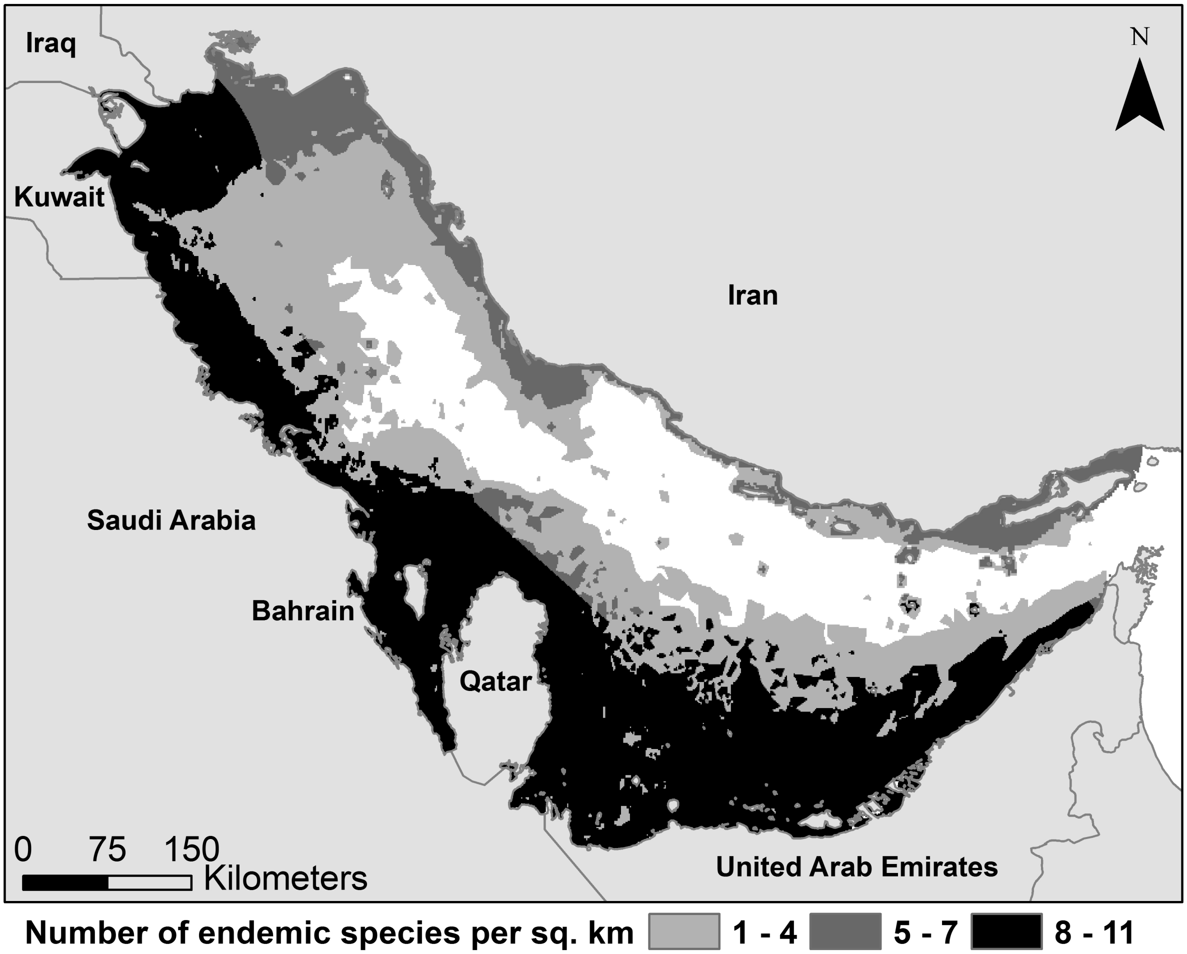


FIG. 8. Species richness of all endemic marine bony fishes in the Gulf.

MAJOR THREATS TO THREATENED MARINE BONY FISHES

Major threats were reviewed for the 31 species assessed to threatened categories (VU or EN). The major threats to marine bony fishes in the Gulf are coastal development, climate change, exploitation, and pollution (Fig. 9). About 84% (26 species) of the threatened species are negatively impacted by multiple major threats. It should be noted that these major threats were identified from primary literature and expert opinion without statistical basis. They have the potential to be interrelated, for example, a near-shore species might be impacted by both coastal development and habitat degradation, but this was not explored.

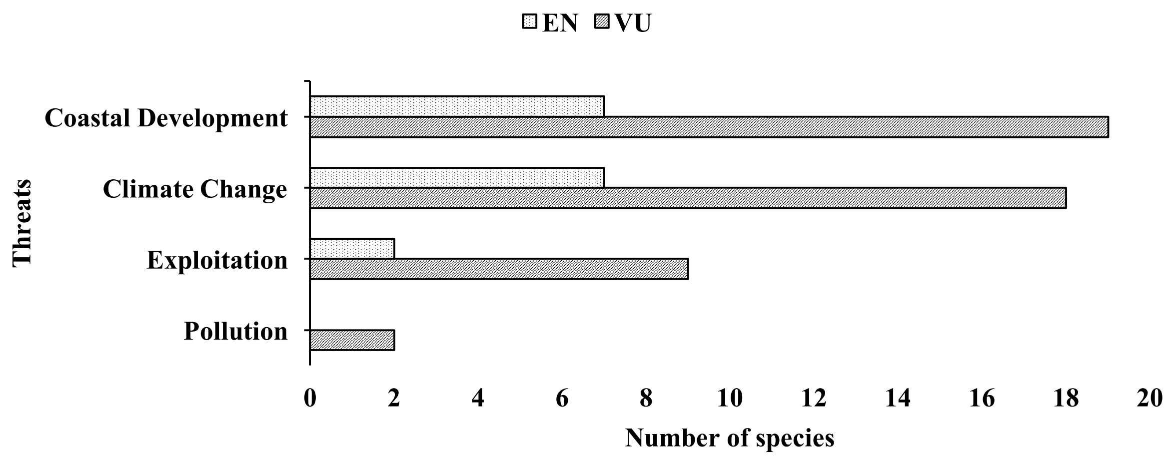


FIG. 9. Major threats to threatened marine bony fishes in the Gulf. Dotted pattern = Endangered (EN), Diagonal lines = Vulnerable (VU).

Coastal Development

The greatest threat facing threatened marine bony fishes in the Gulf is coastal development, which includes direct and indirect disturbances, such as dredging, infilling, reclamation, and increased sedimentation or water flow rates, resulting in habitat degradation and loss. About 84% (26 of 31 species) are negatively affected by coastal development (Fig. 9). Because coastal development involves the removal or degradation of coastal habitats (e.g., near-shore coral assemblages), species that predominately occur in or depend on coastal habitats for survival (e.g., coral dependents) are more impacted by this threat. Coral assemblages are naturally fragmented in the Gulf with the dominant coral-assemblage formation being coral carpets or biostromes (Burt et al., 2014; Purkis and Riegl, 2012). These consist of individual coral colonies, separated by large open areas of sandy habitat. Coral-associated fishes, even highly mobile species, are reluctant to cross open areas, likely due to the reduced structural habitat complexity and perceived risk of predation (Berkström et al., 2013; Chapman and Kramer, 2000; Nash et al., 2015; Shulman, 1985; Sweatman and Robertson, 1994; Turgeon et al., 2010; Welsh and Bellwood, 2012). Thus, continued removal or degradation of coral assemblages would result in declines in these species' populations due to their inability to relocate to nearby remnant coral habitat.

Unfortunately, with the discovery of oil in the 1930s, the Gulf has experienced one of the world's fastest rates of economic gain, resulting in large population growth throughout the region (Burt et al., 2014; Khan, 2007; Sale et al., 2011). With this population growth, increased modification of coastal and near-shore habitats (i.e., infilling, extraction, reclamation, dredging, etc.) took place to accommodate the increase in coastal urbanization (Sale et al., 2011; Sheppard et al., 2010, 1992). The prevalence of coastal modification was so extensive that by the early 1990s, it was estimated that more than 40% of the Gulf's coasts had been modified in some way (Al-Ghadban and Price, 2002). For example, over the past 50 years, the country of Bahrain increased its total land area by approximately 12% through coastal reclamation (Naser, 2011, 2014). Recently, coastal development in the form of mega-scale real estate projects, such as the Palm Islands in Dubai, United Arab Emirates and the Pearl in Doha, Qatar, have become increasingly popular.

In general, the result of the extensive coastal development in the Gulf has been a massive loss in critically important habitats, including coral assemblages, mangroves, and seagrasses (Burt, 2014). However, there are documented cases of developments providing new opportunities for marine biota. Recolonization of hard corals on urban breakwaters at some of the Dubai Palms have been observed (Burt et al., 2009a, 2009b). While these artificial reef ecosystems sometimes had good coral cover, they possessed lower diversity, as well as fish communities that were both structurally and functionally different from nearby natural reefs (Burt et al., 2009a, 2009b). This suggests that while artificial structures may provide new opportunities to marine biota, they are not necessarily replacements for natural habitats.

Climate Change

Nearly 81% (25 of 31 species) of threatened species are impacted by climate change-related disturbances (Fig. 9). The majority of these species (21) are coral-dependent fishes (Buchanan et al., 2016). Recurrent bleaching events due to increased sea surface temperatures (SSTs), which are increasing in frequency and magnitude (Riegl and Purkis, 2015), have resulted in the loss of substantial live coral habitat, particularly in *Acropora* dominated areas (Burt et al., 2008, 2014, 2013; Riegl, 2002; Riegl and Purkis, 2012), reducing the suitable habitat for coral-dependent fishes.

In addition, some marine fishes in the Gulf live near their thermal tolerance limits, as close as 1°C, during parts of the year (Coad, 1992; Price et al., 1993). Thus, as water temperatures continue to increase as a result of climate change, species would be expected to shift their distributions to more preferred temperature regimes (Feary et al., 2014). However, given the overall shallowness of the Gulf, areas of relief from extreme temperatures are limited. Offshore, deeper waters (e.g., deep-water coral assemblages), where temperatures are less extreme, may provide refuge for some species. However, successful immigration to these areas is highly unlikely given the need for individuals to migrate large distances with relatively little protection from predators (Krupp and Müller, 1994). Species already present on these deeper coral assemblages might benefit from the refuge these habitat provide, but these habitats may also become 'cul-de-sacs,' from which species are unable to successfully emigrate (Ben Rais Lasram et al., 2010), potentially resulting in regional extinction. Similar predictions have been made for cold-water marine fishes seeking refuge in the coldest waters of the Mediterranean Sea (Adriatic Sea and Gulf of Lion) (Ben Rais Lasram et al., 2010).

Alternately, individuals may migrate to the Gulf of Oman through the Straits of Hormuz. However, intrinsic and extrinsic factors, such as the pelagic larval duration, swimming ability, resource limitations at settlement, as well as competition with resident species would likely impact the success of migrating individuals (Feary et al., 2014). In addition, differences in environmental and oceanographic conditions experienced in the Straits of Hormuz and the Gulf of Oman may present physiological barriers to immigrating individuals and/or dispersing larvae (Burt et al., 2011). For example, compared to the Gulf, coastal waters of the Gulf of Oman are less saline (averaging 37 ppt) and cooler (ranging from 22-31°C) with mild seasonal changes (Burt et al., 2011). Thus, species unable to adapt or shift their distributions in response to warming water temperatures may be driven towards regional extinction (Ben Rais Lasram et al., 2010).

Exploitation

Globally, the most pervasive threat to marine fishes is overfishing (Dulvy et al., 2009; Harnik et al., 2012; Roberts and Hawkins, 1999). In the Gulf, about 35% (11 of 31 species) of the threatened marine bony fishes are negatively impacted by direct and/or indirect exploitation (Fig. 9). Fisheries are the second most important natural resource and the most important renewable resource in the Gulf (Carpenter et al., 1997b). Along with their contribution to the region's food security, fisheries also provide a source of income, cultural heritage, and recreational opportunities to the Gulf's coastal population (Al-Abdulrazzak et al., 2015; Sheppard et al., 2010). Fisheries of the Gulf are multi-species and multi-gear, and often described as artisanal because of their use of traditional methods. The most common vessels are traditional wooden dhows and fiberglass boats, while the most commonly used gear are hook-and-line, gillnets, hemispherical wire traps (gargoor), and weirs (hadrah) (Grandcourt, 2012).

Increased demand for the Gulf's living marine resources from a growing population, in conjunction with the mechanization of the fishing fleets and enhanced fishing capacities via the introduction of new technology (Grandcourt, 2012), has placed added stress on fisheries stocks. Currently, there is no regional management plan for any stock, despite many stocks being undoubtedly shared between states (Grandcourt, 2012; Morgan, 2006). While each Gulf State has implemented regulations for their respective political jurisdictions, management and enforcement of these is poor (Al-Abdulrazzak et al., 2015; Grandcourt, 2012). Moreover, regulations generally focus on input controls (e.g., gear restrictions) rather than output controls (e.g., size limit, quotas) (Grandcourt, 2012), and most Gulf States (with the exception of the United Arab Emirates) primarily under-report their catch (Al-Abdulrazzak et al., 2015). As a consequence, many fisheries are either fully or overexploited (Grandcourt, 2007b; Morgan, 2006; Samuel et al., 1987; Sheppard et al., 1992).

In addition, there are 34 DD species affected by exploitation, and are listed as DD largely because fisheries data were unavailable or insufficient. Landings are often recorded at the family level, which obscures any species-specific population trends for comparison with the thresholds of criterion A. There is a lack of contemporary stock assessments and detailed catch and effort data for many of the Gulf fisheries, particularly those for reef-associated species (Grandcourt, 2012; Morgan, 2006; Sale et al., 2011). With more species-specific landings statistics, the impact of fishing activities on these DD species could be quantified, potentially increasing the number of species threatened by exploitation.

Pollution

Land and sea based pollution are affecting the fewest threatened marine bony fishes, only 2 of 31 species (Fig. 9). The Mekran Blenny (*Omobranchus mekranensis*) was listed as threatened based on the impact of pollution, as it is only known from the Manifa Oil Fields in Saudi Arabia. Thus, an oil spill that completely covers its distribution presents a serious plausible threat. With 800 offshore platforms supported by 25,000 annual tanker shipments, the Gulf produces almost a third of the world's oil supply (Van Lavieren et al., 2011). Thus, Gulf marine environments experience chronic oil pollution through ballast water discharge, underwater pipeline and oil well blowouts, and other related causes (Naser, 2011). However, there is a high concentration of oil-degrading bacteria in sediments, which are able to convert oil into a food source for detritivores such as worms and shrimps (Carpenter et al., 1997b). The presence of such high concentrations of oil-degrading bacteria is likely because of the natural seepage of oil, which accounts for about 10% of the total oil spilled in the Gulf (Literathy, 1993). With such constant exposure to oil, both fishes and non-fishes are presumably tolerant of it to a certain extent (Carpenter et al., 1997b). Thus, it is not surprising that so few species are not undergoing population declines sufficient to qualify as regionally threatened based on oil pollution alone.

The other threatened species impacted by pollution was the Silver Pomfret (*Pampus argenteus*). This species was listed as threatened due to overfishing with pollution (mainly discharged wastewater from desalination plants influencing the salinity of nursery habitat) as a secondary threat. However, the extent of this impact on *P. argenteus* is currently unknown. Nearly half of the world's desalinated water supply is produced annually in the Gulf (Burt, 2014) and at least twice as much wastewater is produced as a byproduct of the process (Höpner and Lattemann, 2002). Plumes of discharged wastewater, generally higher in temperature and salinity and containing a number of chemical and heavy metal pollutants, can have deleterious effects on marine environments and their inhabitants several kilometers from their source (Dawoud and Al-Mulla, 2012; Lattemann and Höpner, 2008). Along with oil and effluents from desalination plants, residential and commercial wastewater, including sewage and effluents from power plants, industrial plants, and agriculture have also increased as a result of the increased human presence in the region (Carpenter et al., 1997b).

CONSERVATION AND MANAGEMENT

Marine Bony Fishes in Gulf Protected Areas

Currently, marine protected areas cover around 7.2% of the Gulf's maritime area (Al-Cibahy et al., 2012). However, the management effectiveness of Gulf MPAs varies (Van Lavieren and Klaus, 2013). A number of weaknesses have been identified, including poor enforcement of regulations, lack of management plans, inadequate boundary demarcation, and weak communication with local stakeholder, traditional communities and local marine resource users (Van Lavieren and Klaus, 2013). Despite this, MPAs in the Gulf have been successful in protecting some species. For example, in the southern Gulf, reef fish biomass density per unit area is significantly greater on protected reefs compared to unprotected reefs, and many commercially important species were larger in size on reefs within MPAs compared to reefs open to exploitation (Grandcourt, 2012). However, the vast majority of these species, 438 to be exact, have 5% or less of their range covered. This comes to no surprise as most marine bony fishes (>300 species) in the Gulf have widespread distributions, while the current MPA network only covers a small percentage of the Gulf waters. Only one species, *Bryaninops amplus* (assessed as DD), has its range completely covered by a MPA. However, it is only known in the Gulf from a limited number of records at a single locality and thus may be more widely distributed than is currently known.

Seventeen species, for which distribution information within the Gulf was available, were not protected within any MPAs (Table 3). Of these, nine were listed as DD, seven as LC, and one as VU. These gap species all have restricted ranges (< 750 km^2) and are concentrated at Jana Island, Saudi Arabia (Fig. 10). Prioritizing this offshore island, which contains robust coral and fish assemblages (Rezai et al., 2004), for conservation would not only benefit these gap species, but also other species which utilize its coral habitat (e.g., coral dependents).

Table 3. Marine bony fishes identified as gap species in the Gulf. IUCN Red List Category for each species also listed.

Order	Family	Species	IUCN Red List Category
Anguilliformes	Muraenidae	*Gymnothorax herrei*	DD
Anguilliformes	Ophichthidae	*Brachysomophis cirrocheilos*	DD
Clupeiformes	Engraulidae	*Encrasicholina heteroloba*	DD
Perciformes	Apogonidae	*Pseudamia tarri*	LC
Perciformes	Blenniidae	*Omobranchus mekranensis*	VU
Perciformes	Callionymidae	*Callionymus marleyi*	LC
Perciformes	Carangidae	*Trachinotus baillonii*	LC
Perciformes	Gobiidae	*Fusigobius inframaculatus*	LC
Perciformes	Gobiidae	*Tomiyamichthys latruncularius*	LC
Perciformes	Labridae	*Paracheilinus mccoskeri*	LC
Perciformes	Opistognathidae	*Opistognathus muscatensis*	DD
Pleuronectiformes	Bothidae	*Grammatobothus polyophthalmus*	DD
Pleuronectiformes	Citharidae	*Brachypleura novaezeelandiae*	LC
Pleuronectiformes	Soleidae	*Aesopia cornuta*	DD
Syngnathiformes	Syngnathidae	*Acentronura tentaculata*	DD
Syngnathiformes	Syngnathidae	*Choeroichthys brachysoma*	DD
Syngnathiformes	Syngnathidae	*Doryrhamphus excisus*	DD

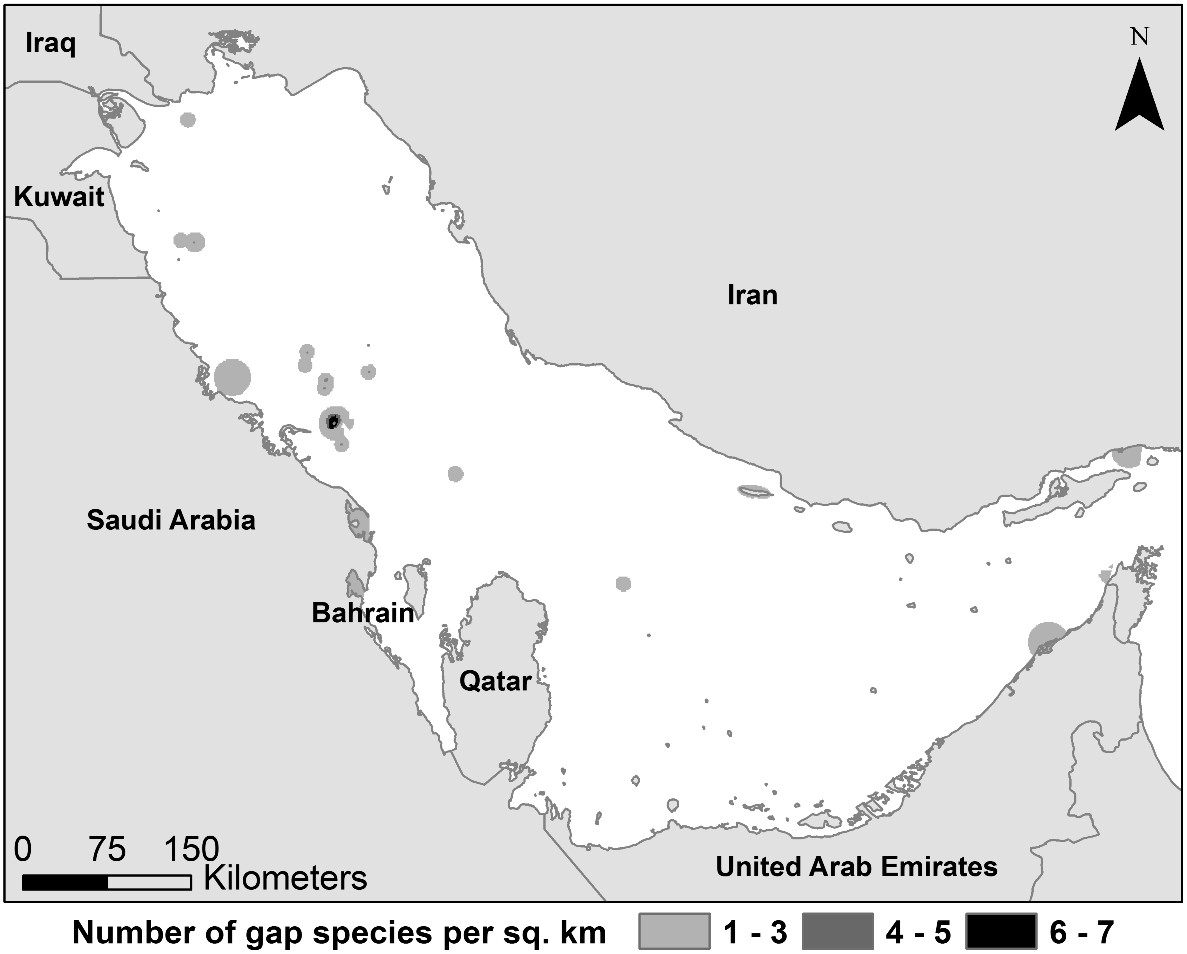


FIG. 10. Species richness of unrepresented (gap) marine bony fishes in Gulf marine protected areas (MPAs).

Critical Habitats in Gulf Protected Areas

A number of marine bony fishes utilize critical habitats during part or their entire ontogeny (e.g., coral dependents). Thus, it is also important to consider the coverage of critical habitats within protected areas. Mangroves have the highest proportion of overlap with protected areas, about 51% (Fig. 11). Protected areas cover about 25% and 10% of seagrass and coral habitats, respectively. Like the marine bony fishes, these critical habitats are threatened by climate change and a variety of anthropogenic disturbances (Burt, 2014; Burt et al., 2014).

Coastal development, freshwater extraction, and oil pollution have degraded and reduced mangrove habitat in the Gulf (Sheppard et al., 2010). For example, in Tubli Bay, Bahrain, construction of causeways, highways, and residential housing reduced mangrove area from 25 km^2 to 13 km^2 in 2006 (CBD, 2006b; Van Lavieren et al., 2011). Fortunately, afforestation, establishing mangrove habitats in areas where they previously did not occur, has become increasingly popular as a form of aesthetic enhancement of coastal areas (Spalding et al., 2010). While this has resulted in localized increases in mangrove habitat, it is important to ensure the impacts to nearby established habitats (e.g., seagrasses) are mitigated.

Seagrass habitat has also experienced degradation and fragmentation in the Gulf. Localized impacts to seagrass habitats from coastal development (dredging and land reclamation), power and desalination plants, and oil exploration and spills have increased dramatically in the recent decades (Erftemeijer and Shuail, 2012). For example, coastal reclamation and dredging in Bahrain between 1985 and 1992 resulted in the loss of about 10 km^2 of seagrass habitat in Fasht al-Adhm (Al-Madany et al., 1991; Zainal et al., 1993).

Historical estimates suggest the Gulf once contained approximately 3,800 km^2 of coral habitat (Burt, 2014). However, widespread anthropogenic impacts and thermal stress have resulted in extensive degradation, with more than 85% of natural coral habitat considered threatened in the Gulf (Burke et al., 2011). Declines over the past few decades suggest that about 70% of coral habitat in the Gulf is effectively lost (Burt et al., 2014).

With such widespread degradation of these critically important habitats, the Gulf is considered among the most degraded marine eco-regions in the world (Halpern et al., 2008). Thus, it is imperative for future conservation efforts to include these critical habitats in their plans. However, these plans must ensure that legislative and regulatory frameworks as well as enforcement are sufficient to mitigate threats to these habitats and their inhabitants.

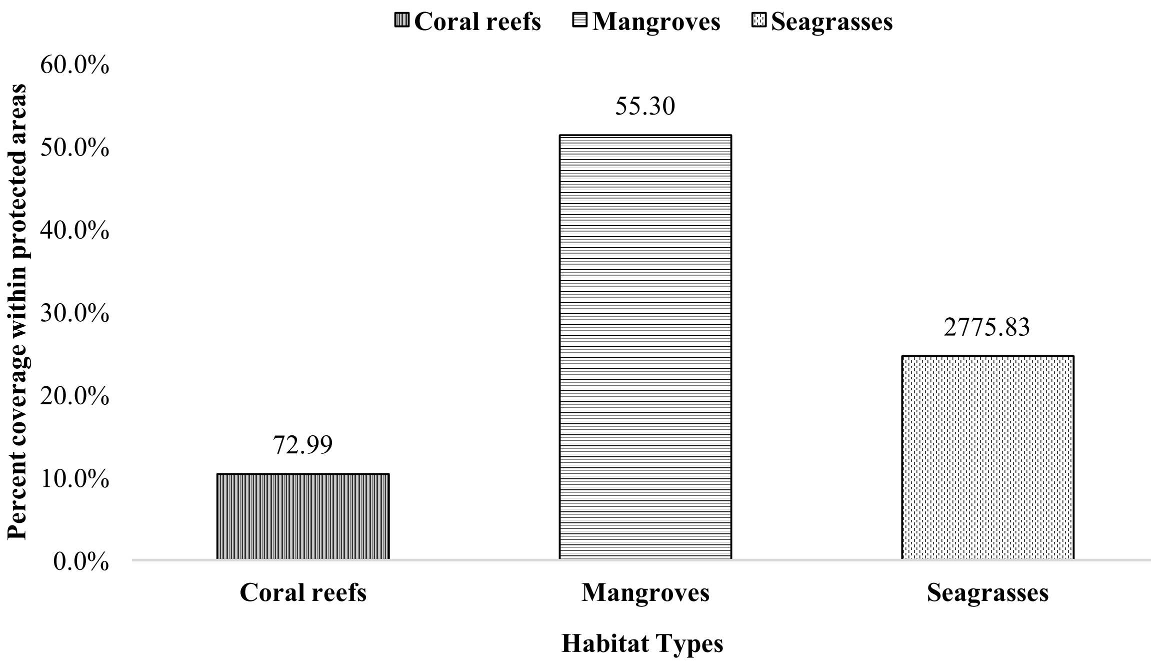


FIG. 11. Percent coverage of critical habitats within Gulf protected areas. Total area (in km^2) of each habitat within protected areas are displayed above their respective column.

Structure of Gulf Fish Assemblages

Marine bony fish assemblages in the Gulf's species richness hotspots were comparable, with 92% similarity across all 21 sites (Fig. 12). This high degree of similarity is likely due to the widespread distributions of most of the marine bony fishes. Such high similarity also suggests that protected areas would likely provide similar benefits to species diversity regardless of location.

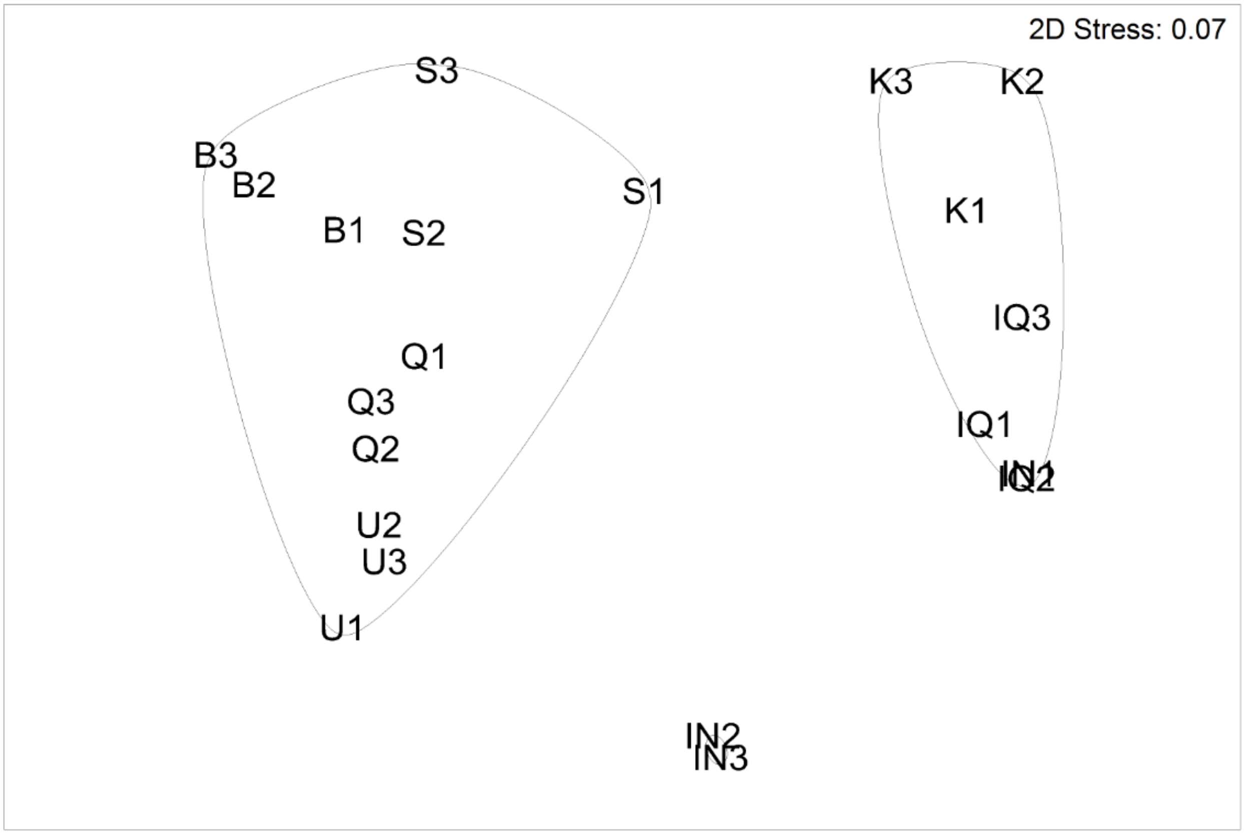


FIG. 12. MDS ordination of fish communities at each Gulf site. Three groups from cluster analysis are indicated, with 94% similarity.

However, three distinct fish assemblages were identified with 94% similarity (Fig. 12), and can be identified geographically as the northern Gulf (northern Iran, Iraq and Kuwait), western Gulf (Saudi Arabia, Bahrain, Qatar and the United Arab Emirates) and southern Iran. These assemblages were driven by 30 species (Table 4) that explained 67% of the variation in community structure. Fish assemblages in the northern Gulf are influenced by the Tigris and Euphrates Rivers, which enter the northern Gulf via the largest and most important estuary in the Gulf, the Shatt Al-Arab (Sheppard et al., 2010). Here the highly saline Gulf waters are considerably diluted by the influx of freshwater. A number of fishes utilize this estuarine habitat as breeding and/or nursery grounds (e.g., estuarine-dependent *Pampus argenteus*). In the western

Gulf, conditions become more extreme towards the south, however, offshore coral assemblages provide more stable conditions allowing for some of the most diverse coral and fish assemblages in the Gulf (Coles and Tarr, 1990). In southeastern Iran, conditions are influenced by the influx of oceanic water inflowing through the Straits of Hormuz (Price et al., 1993). Thus, fish assemblages tend to be rich and more similar to those found in the Gulf of Oman (Burt et al., 2011).

Table 4. List of marine bony fishes identified by Principle Component Analysis (PCA) as the drivers of the differences among fish community structure groups in the Gulf. Their IUCN Red List Category is also provided.

Order	Family	Species	IUCN Red List Category
Batrachoidiformes	Batrachoididae	*Colletteichthys occidentalis*	LC
Beloniformes	Exocoetidae	*Cypselurus oligolepis*	LC
Beloniformes	Exocoetidae	*Parexocoetus mento*	LC
Clupeiformes	Clupeidae	*Anodontostoma chacunda*	LC
Clupeiformes	Clupeidae	*Nematalosa persara*	DD
Mugiliformes	Mugilidae	*Liza abu*	LC
Perciformes	Apogonidae	*Cheilodipterus macrodon*	LC
Perciformes	Apogonidae	*Fowleria vaiulae*	LC
Perciformes	Blenniidae	*Antennablennius simonyi*	DD
Perciformes	Callionymidae	*Diplogrammus pygmaeus*	LC
Perciformes	Epinephelidae	*Epinephelus epistictus*	DD
Perciformes	Gobiidae	*Asterropteryx semipunctata*	LC
Perciformes	Gobiidae	*Coryogalops monospilus*	DD
Perciformes	Gobiidae	*Gnatholepis caudimacula*	LC
Perciformes	Haemulidae	*Pomadasys argenteus*	LC
Perciformes	Labridae	*Halichoeres leptotaenia*	LC
Perciformes	Mullidae	*Mulloidichthys flavolineatus*	DD
Perciformes	Pseudochromidae	*Pseudochromis linda*	LC
Perciformes	Pseudochromidae	*Pseudochromis nigrovittatus*	LC
Perciformes	Sciaenidae	*Johnius belangerii*	LC
Perciformes	Sciaenidae	*Johnius sina*	DD
Perciformes	Sciaenidae	*Pennahia anea*	LC
Perciformes	Sciaenidae	*Protonibea diacanthus*	LC
Perciformes	Stromateidae	*Pampus argenteus*	VU
Perciformes	Tripterygiidae	*Helcogramma steinitzi*	LC
Pleuronectiformes	Soleidae	*Solea stanalandi*	DD
Pleuronectiformes	Soleidae	*Zebrias synapturoides*	DD
Syngnathiformes	Fistulariidae	*Fistularia petimba*	LC
Syngnathiformes	Syngnathidae	*Cosmocampus investigatoris*	LC
Syngnathiformes	Syngnathidae	*Hippocampus kuda*	DD

Recommendations for Gulf Conservation Priorities

Given the fish community structure is very similar throughout the Gulf, areas of high endemic and threatened species and critical habitats should be the focus of future conservation efforts (Fig. 13a-c). For example, near-shore areas around the Kuwait/Iraq border contain both high endemic and threatened species diversity as well as large stands of seagrass beds (Fig. 13a).

(a)

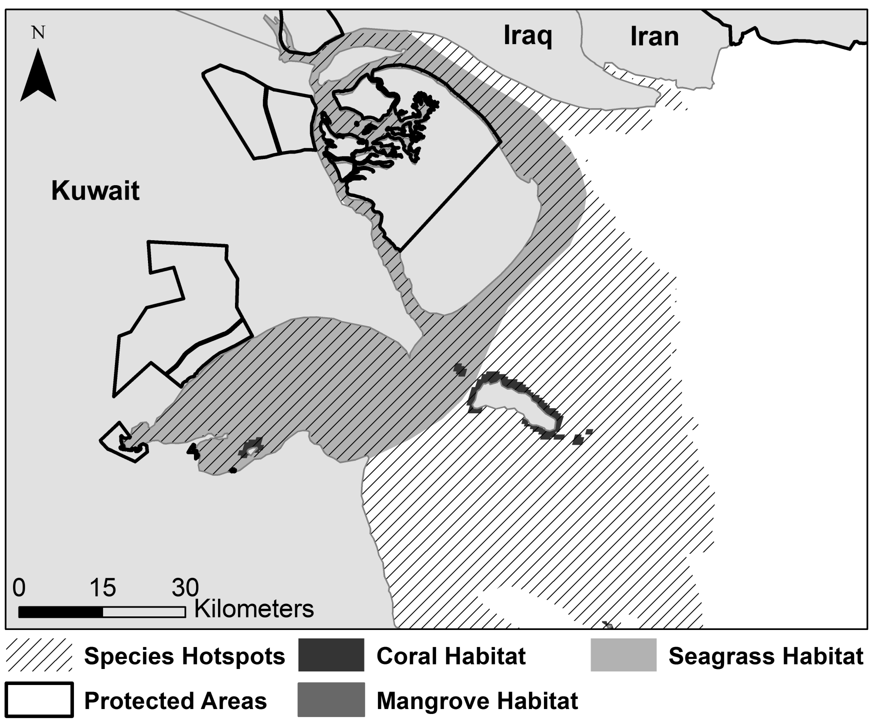
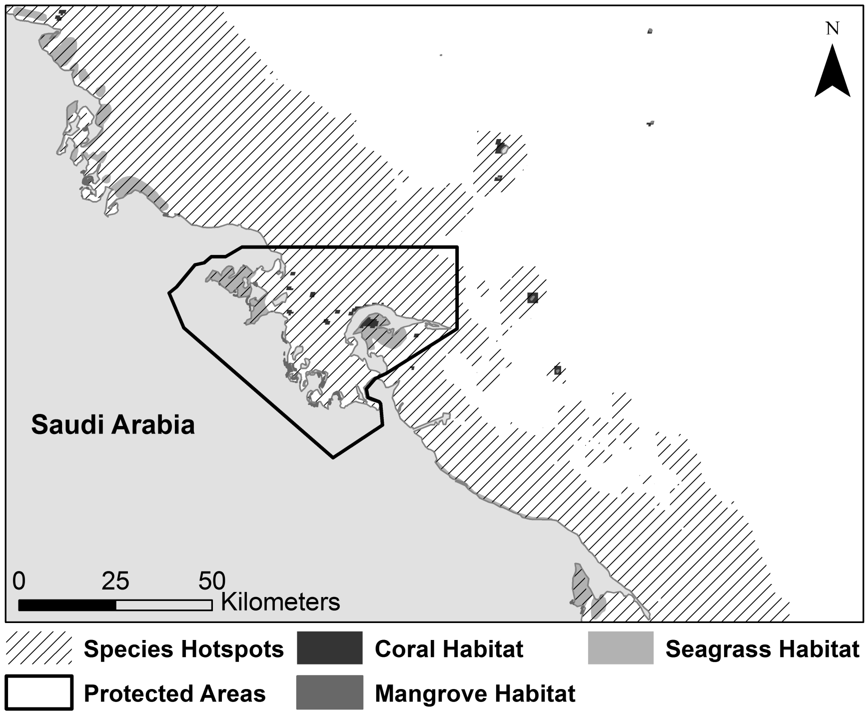


FIG. 13. Areas in need of future conservation priority; (a) Near-shore areas around Kuwait/Iraq border, (b) offshore islands of Saudi Arabia and Iran, (c) near-shore areas of Abu Dhabi, UAE. For visualization purposes, a 1-km buffer was placed around mangrove habitat. Data Sources: Giri et al., 2011; IUCN and UNEP-WCMC, 2015; UNEP-WCMC and Short, 2005; UNEP-WCMC et al., 2010.

(b)



(c)

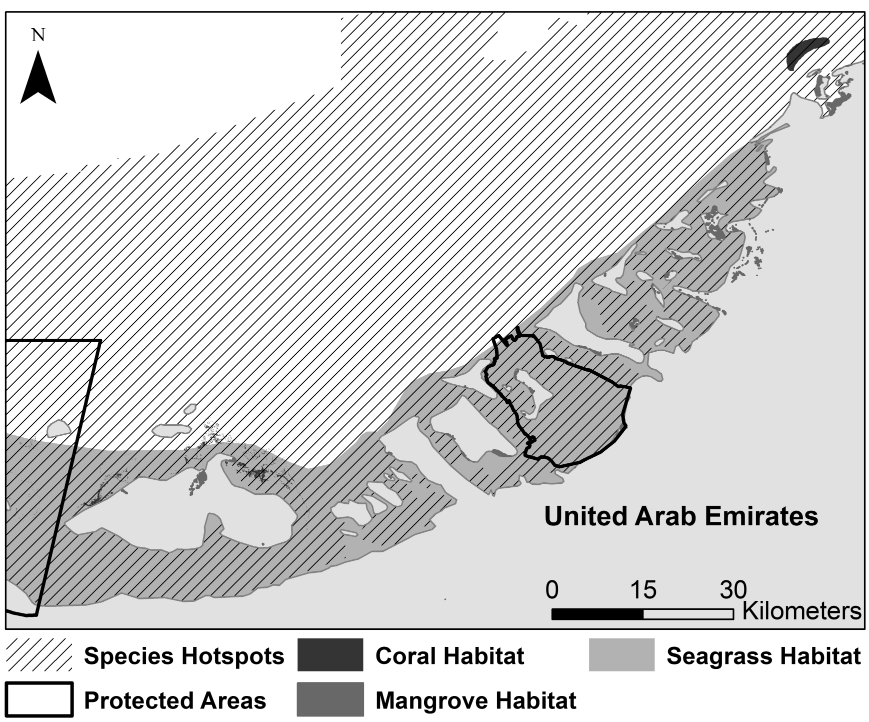


FIG. 13. Continued.

Similarly, the offshore coral islands, particularly those of Saudi Arabia and Iran, should also be considered priorities for conservation (Fig. 13b). In terms of gap species, Jana Island, Saudi Arabia is especially important, as it contains the highest number of currently unprotected species.

In the southern Gulf, the near-shore areas around Abu Dhabi, United Arab Emirates were highlighted as urgent priorities (Fig. 13c). These areas contain both high endemic and threatened species richness and all three critical habitats. Of particular importance is the large concentration of mangrove habitat, which accounts for about 85% of the total mangrove area found in the United Arab Emirates (Abdessalaam, 2007), and about 31% of the total mangrove area in the Gulf.

However, it is important to stress that these highlighted areas should not be considered the only areas in need of urgent conservation action. Moreover, if a site was not highlighted as a priority that does not mean it should not receive conservation attention. Our results only cover the marine bony fishes and their critical habitats. Thus, similar analyses should be conducted for other taxonomic clades and/or habitats, as there are likely a number of other areas in the Gulf that are equally deserving of conservation action that are not identified here.

DATA GAPS

Several data gaps were identified during the course of this study. The critical habitat data from UNEP-WCMC utilized in this study are outdated and originally based on anecdotal reports rather than actual mapping exercises (Giri et al., 2011; UNEP-WCMC and Short, 2005; UNEP-WCMC et al., 2010). Thus, the data do not capture the recent degradation and loss of these critical habitats. In addition, omission of coral assemblages were identified, specifically at Harqus, Jana, Jurayd, and Kubbar islands. Although these coral assemblages were added prior to completion of the analyses (Buchanan et al., 2016), the possibility that there are additional, unidentified omissions cannot be discounted. Therefore, the amount of critical habitat covered within protected areas is likely overestimated. To address this uncertainty, an integrated regional mapping effort for Gulf critical habitats is urgently needed. While several Gulf States have mapped at least some of their critical habitats, much of the distribution and quality of data are already outdated because of the recent bleaching events and anthropogenic impacts. Thus, a Gulf-wide critical habitat mapping exercise is pivotal in determining the true distribution of these habitats, and thus where protected areas should be prioritized (Grizzle et al., 2016).

Surveys within poorly studied areas (e.g., offshore islands of Iran) are also needed, as sampling bias was prominent in our analyses. They would provide valuable insights into the critical habitat and fish assemblages, as well as provide a more accurate assessment of the Gulf's diversity. They may also increase the information available for the species assessed as DD, which have the potential to be threatened or not; however, until sufficient data for these species are available, their status will remain unknown. Thus, there is a need for a biodiversity assessment of these poorly studied areas, perhaps in concert with a Gulf-wide mapping effort as a ground truthing exercise.

For future conservation actions to be successful, it is essential that Gulf States increase their own individual efforts, as well as cross-boundary collaboration. Historically, such collaboration has been a challenge, an issue that is reiterated in the literature often (Buchanan et al., 2016; Burt, 2013; Burt et al., 2014; Feary et al., 2013; Krupp, 2002, 2008; Krupp et al., 2009, 2006; Sheppard et al., 2012; Vaughan and Burt, 2016). Threats to marine bony fishes, and marine biodiversity as a whole, are not bounded by national jurisdictions, but are common across all nations in the Gulf. Thus, enhanced trans-regional collaboration among the scientific community will help to promote the development of proactive strategies to mitigate the impacts of these threats.

CONCLUSIONS

This is the first study to assess the conservation status of all Gulf marine bony fishes at the regional level. Despite multiple anthropogenic stressors and extreme environmental conditions in the Gulf, the majority of marine bony fishes are not in immediate threat of regional extinction. However, this does not suggest that they are not in need of conservation – the opposite is true. Gulf marine habitats and species are subjected to naturally extreme environmental conditions, which are not expected to be seen in other similar sea areas for decades (Burt et al., 2011; Feary et al., 2012). We must take advantage of this living laboratory to understand how these habitats and their inhabitants function and adapt to these extremes, from the molecular to the ecosystem level (Burke et al., 2011; Sheppard et al., 2012). Such information could provide valuable insight into how marine habitats and species in other parts of the world may respond to future climate change.

This study also identified several critical next steps that must be addressed for the Gulf. For conservation prioritization to be efficient and effective across all marine taxa, we must know the extent of marine biodiversity throughout the Gulf, specifically in poorly studied areas, such as the offshore islands and near-shore habitats of Iran. This research could be conducted in tandem with an integrated Gulf-wide mapping effort, which would greatly benefit regional conservation actions by providing an accurate, high-resolution picture of the status and distribution of critical habitats. These opportunities to conduct research in this unique marine environment, where so much remains to be learned, will provide essential information for the conservation of the Gulf and all marine environments.

REFERENCES

Abdessalaam, T.Z. Al, 2007. Coastal and Marine Habitats, in: Abdessalaam, T.Z. Al (Ed.), Marine Environment and Resources of Abu Dhabi. Environment Agency - Abu Dhabi (EAD) and Motivate Publishing, Abu Dhabi, pp. 54–91.

Abdullah, M., Al-Muhanadi, M., Falamarzi, M., Al-Binali, A.R., Al-Khalaf, K., 2010. Stock assessment and management of commercial fish resources in Qatar. Part 1 - Current status of ten fish stocks. Technical Report, Fisheries Management Department, Ministry of Environment, State of Qatar.

Al-Abdulrazzak, D., Zeller, D., Belhabib, D., Tesfamichael, D., Pauly, D., 2015. Total marine fisheries catches in the Persian/Arabian Gulf from 1950 to 2010. Reg. Stud. Mar. Sci. 2, 28–34. doi:10.1016/j.rsma.2015.08.003

Al-Cibahy, A.S., Al-Khalifa, K., Böer, B., Samimi-Namin, K., 2012. Conservation of marine ecosystems with a special view to coral reefs in the Gulf, in: Riegl, B.M., Purkis, S.J. (Eds.), Coral Reefs of the Gulf: Adaptations to Climatic Extremes. Springer Science+Business Media B. V., pp. 337–348.

Al-Ghadban, A.N., Price, A.R.G., 2002. Dredging and infilling, in: Khan, N.Y., Munwar, M., Price, A.R.G. (Eds.), The Gulf Ecosystem Health and Sustainability. pp. 207–218.

Al-Madany, I.M., Abdalla, M.A., Abdu, A.S.E., 1991. Coastal zone management in Bahrain: an analysis of social, economic and environmental impacts of dredging and reclamation. J. Environ. Manage. 32, 335–348.

Amante, C., Eakins, B.W., 2009. ETOPO1 1 Arc-Minute Global Relief Model: Procedures, Data Sources and Analysis. NOAA Technical Memorandum NESDIS NGDC-24. National Geophysical Data Center, NOAA. doi:10.7289/V5C8276M [10 November 2015].

Araújo, M.B., Lobo, J.M., Moreno, J.C., 2007. The effectiveness of Iberian protected areas in conserving terrestrial biodiversity. Conserv. Biol. 21, 1423–1432. doi:10.1111/j.1523-1739.2007.00827.x

Austin, M.P., Margules, C.R., 1986. Assessing Representativeness, in: Usher, M.B. (Ed.), Wildlife Conservation Evaluation. Springer Netherlands, pp. 45–67.

Basson, P.W., Burchard, J.E., Hardy, J.T., Price, A.R.G., 1977. Biotopes of the Western Arabian Gulf: Marine Life and Environments of Saudi Arabia. ARAMCO, Dhahran, Saudi Arabia.

Ben Rais Lasram, F., Guilhaumon, F., Albouy, C., Somot, S., Thuiller, W., Mouillot, D., 2010. The Mediterranean Sea as a “cul-de-sac” for endemic fishes facing climate change. Glob. Chang. Biol. 16, 3233–3245. doi:10.1111/j.1365-2486.2010.02224.x

Berkström, C., Lindborg, R., Thyresson, M., Gullström, M., 2013. Assessing connectivity in a tropical embayment: Fish migrations and seascape ecology. Biol. Conserv. 166, 43–53. doi:10.1016/j.biocon.2013.06.013

Böhm, M., Collen, B., Baillie, J.E.M., Bowles, P., Chanson, J., Cox, N., Hammerson, G., Hoffmann, M., Livingstone, S.R., Ram, M., Rhodin, A.G.J., Stuart, S.N., van Dijk, P.P., Young, B.E., Afuang, L.E., Aghasyan, A., García, A., Aguilar, C., Ajtic, R., Akarsu, F., Alencar, L.R.V., Allison, A., Ananjeva, N., Anderson, S., Andrén, C., Ariano-Sánchez, D., Arredondo, J.C., Auliya, M., Austin, C.C., Avci, A., Baker, P.J., Barreto-Lima, A.F., Barrio-Amorós, C.L., Basu, D., Bates, M.F., Batistella, A., Bauer, A., Bennett, D., Böhme, W., Broadley, D., Brown, R., Burgess, J., Captain, A., Carreira, S., Castañeda, M.D.R., Castro, F., Catenazzi, A., Cedeño-Vázquez, J.R., Chapple, D.G., Cheylan, M., Cisneros-Heredia, D.F., Cogalniceanu, D., Cogger, H., Corti, C., Costa, G.C., Couper, P.J., Courtney, T., Crnobrnja-Isailovic, J., Crochet, P.-A., Crother, B., Cruz, F., Daltry, J.C., Daniels, R.J.R., Das, I., de Silva, A., Diesmos, A.C., Dirksen, L., Doan, T.M., Dodd, C.K., Doody, J.S., Dorcas, M.E., Duarte de Barros Filho, J., Egan, V.T., El Mouden, E.H., Embert, D., Espinoza, R.E., Fallabrino, A., Feng, X., Feng, Z.-J., Fitzgerald, L., Flores-Villela, O., França, F.G.R., Frost, D., Gadsden, H., Gamble, T., Ganesh, S.R., Garcia, M.A., García-Pérez, J.E., Gatus, J., Gaulke, M., Geniez, P., Georges, A., Gerlach, J., Goldberg, S., Gonzalez, J.-C.T., Gower, D.J., Grant, T., Greenbaum, E., Grieco, C., Guo, P., Hamilton, A.M., Hare, K., Hedges, S.B., Heideman, N., Hilton-Taylor, C., Hitchmough, R., Hollingsworth, B., Hutchinson, M., Ineich, I., Iverson, J., Jaksic, F.M., Jenkins, R., Joger, U., Jose, R., Kaska, Y., Kaya, U., Keogh, J.S., Köhler, G., Kuchling, G., Kumlutaş, Y., Kwet, A., La Marca, E., Lamar, W., Lane, A., Lardner, B., Latta, C., Latta, G., Lau, M., Lavin, P., Lawson, D., LeBreton, M., Lehr, E., Limpus, D., Lipczynski, N., Lobo, A.S., López-Luna, M.A., Luiselli, L., Lukoschek, V., Lundberg, M., Lymberakis, P., Macey, R., Magnusson, W.E., Mahler, D.L., Malhotra, A., Mariaux, J., Maritz, B., Marques, O.A.V., Márquez, R., Martins, M., Masterson, G., Mateo, J.A., Mathew, R., Mathews, N., Mayer, G., McCranie, J.R., Measey, G.J., Mendoza-Quijano, F., Menegon, M., Métrailler, S., Milton, D.A., Montgomery, C., Morato, S.A.A., Mott, T., Muñoz-Alonso, A., Murphy, J., Nguyen, T.Q., Nilson, G., Nogueira, C., Núñez, H., Orlov, N., Ota, H., Ottenwalder, J., Papenfuss, T., Pasachnik, S., Passos, P., Pauwels, O.S.G., Pérez-Buitrago, N., Pérez-Mellado, V., Pianka, E.R., Pleguezuelos, J., Pollock, C., Ponce-Campos, P., Powell, R., Pupin, F., Quintero Díaz, G.E., Radder, R., Ramer, J., Rasmussen, A.R., Raxworthy, C., Reynolds, R., Richman, N., Rico, E.L., Riservato, E., Rivas, G., da Rocha, P.L.B., Rödel, M.-O., Rodríguez Schettino, L., Roosenburg, W.M., Ross, J.P., Sadek, R., Sanders, K., Santos-Barrera, G., Schleich, H.H., Schmidt, B.R., Schmitz, A., Sharifi, M., Shea, G., Shi, H.-T., Shine, R., Sindaco, R., Slimani, T., Somaweera, R., Spawls, S., Stafford, P., Stuebing, R., Sweet, S., Sy, E., Temple, H.J., Tognelli, M.F., Tolley, K., Tolson, P.J., Tuniyev, B., Tuniyev, S., Üzüm, N., van Buurt, G., Van Sluys, M., Velasco, A., Vences, M., Veselý, M., Vinke, S., Vinke, T., Vogel, G., Vogrin, M., Vogt, R.C., Wearn, O.R., Werner, Y.L., Whiting, M.J., Wiewandt, T., Wilkinson, J., Wilson, B., Wren, S., Zamin, T., Zhou, K., Zug, G., 2013. The conservation status of the world's reptiles. Biol. Conserv. 157, 372–385. doi:10.1016/j.biocon.2012.07.015

Buchanan, J.R., Krupp, F., Burt, J.A., Feary, D.A., Ralph, G.M., Carpenter, K.E., 2016. Living on the edge: Vulnerability of coral-dependent fishes in the Gulf. Mar. Pollut. Bull. 105, 480–488. doi:10.1016/j.marpolbul.2015.11.033

Burke, L., Reytar, K., Spalding, M., Perry, A., 2011. Reefs at risk Revisited. Defenders 74, 130. doi:10.1016/0022-0981(79)90136-9

Burt, J., Bartholomew, A., Bauman, A., Saif, A., Sale, P.F., 2009a. Coral recruitment and early benthic community development on several materials used in the construction of artificial reefs and breakwaters. J. Exp. Mar. Bio. Ecol. 373, 72–78. doi:10.1016/j.jembe.2009.03.009

Burt, J., Bartholomew, A., Usseglio, P., 2008. Recovery of corals a decade after a bleaching event in Dubai, United Arab Emirates. Mar. Biol. 154, 27–36. doi:10.1007/s00227-007-0892-9

Burt, J., Bartholomew, A., Usseglio, P., Bauman, A., Sale, P.F., 2009b. Are artificial reefs surrogates of natural habitats for corals and fish in Dubai, United Arab Emirates? Coral Reefs 28, 663–675. doi:10.1007/s00338-009-0500-1

Burt, J.A., 2014. The environmental costs of coastal urbanization in the Arabian Gulf. City 18, 760–770. doi:10.1080/13604813.2014.962889

Burt, J.A., 2013. The growth of coral reef science in the Gulf: A historical perspective. Mar. Pollut. Bull. 72, 289–301. doi:10.1016/j.marpolbul.2013.05.016

Burt, J.A., Al-Khalifa, K., Khalaf, E., AlShuwaikh, B., Abdulwahab, A., 2013. The continuing decline of coral reefs in Bahrain. Mar. Pollut. Bull. 72, 357–363. doi:10.1016/j.marpolbul.2012.08.022

Burt, J.A., Feary, D.A., Bauman, A.G., Usseglio, P., Cavalcante, G.H., Sale, P.F., 2011. Biogeographic patterns of reef fish community structure in the northeastern Arabian Peninsula. ICES J. Mar. Sci. 68, 1875–1883. doi:10.1093/icesjms/fsr129

Burt, J.A., Van Lavieren, H., Feary, D.A., 2014. Persian Gulf reefs: An important asset for climate science in urgent need of protection. Ocean Chall. 20, 49–56.

Butchart, S.H.M., Clarke, M., Smith, R.J., Sykes, R.E., Scharlemann, J.P.W., Harfoot, M., Buchanan, G.M., Angulo, A., Balmford, A., Bertzky, B., Brooks, T.M., Carpenter, K.E., Comeros-Raynal, M.T., Cornell, J., Ficetola, G.F., Fishpool, L.D.C., Fuller, R.A., Geldmann, J., Harwell, H., Hilton-Taylor, C., Hoffmann, M., Joolia, A., Joppa, L., Kingston, N., May, I., Milam, A., Polidoro, A., Ralph, A., Richman, N., Rondinini, C., Segan, D., Skolnik, B., Spalding, M., Stuart, S.N., Symes, A., Taylor, J., Visconti, P., Watson, J., Wood, L., Burgess, N.D., 2015. Shortfalls and solutions for meeting national and global conservation area targets. Conserv. Lett. 1–9. doi:10.1111/conl.12158

Butchart, S.H.M., Walpole, M., Collen, B., Strien, A. Van, Scharlemann, J.P.W., Rosamunde, E.A., Baillie, J.E.M., Bomhard, B., Brown, C., Bruno, J., Carpenter, K.E., Carr, M., Chanson, J., Chenery, A.M., Csirke, J., Davidson, N.C., Dentener, F., Foster, M., Galli, A., Galloway, J.N., Genovesi, P., Gregory, R.D., Hockings, M., Lamarque, J., Leverington, F., Loh, J., Mcgeoch, M.A., Mcrae, L., Minasyan, A., Morcillo, M.H., Oldfield, T.E.E., Pauly, D., Quader, S., Revenga, C., Sauer, J.R., Skolnik, B., Spear, D., Stanwell-Smith, D., Simon, N., Symes, A., Tierney, M., Tyrrell, T.D., Vié, J.-C., Watson, R., 2010. Global Biodiversity: Indicators of Recent Declines. Science (80-.). 328, 1164–1168.

Cardinale, B.J., Duffy, J.E., Gonzalez, A., Hooper, D.U., Perrings, C., Venail, P., Narwani, A., Mace, G.M., Tilman, D., A.Wardle, D., Kinzig, A.P., Daily, G.C., Loreau, M., Grace, J.B., Larigauderie, A., Srivastava, D.S., Naeem, S., 2012. Biodiversity loss and its impact on humanity. Nature 489, 326–326. doi:10.1038/nature11373

Carpenter, K.E., Abrar, M., Aeby, G., Aronson, R.B., Banks, S., Bruckner, A., Chiriboga, A., Cortés, J., Delbeek, J.C., Devantier, L., Edgar, G.J., Edwards, A.J., Fenner, D., Guzmán, H.M., Hoeksema, B.W., Hodgson, G., Johan, O., Licuanan, W.Y., Livingstone, S.R., Lovell, E.R., Moore, J.A., Obura, D.O., Ochavillo, D., Polidoro, B.A., Precht, W.F., Quibilan, M.C., Reboton, C., Richards, Z.T., Rogers, A.D., Sanciangco, J., Sheppard, A., Sheppard, C., Smith, J., Stuart, S., Turak, E., Veron, J.E.N., Wallace, C., Weil, E., Wood, E., 2008. One-third of reef-building corals face elevated extinction risk from climate change and local impacts. Science (80-.). 321, 560–563. doi:10.1126/science.1159196

Carpenter, K.E., Harrison, P.L., Hodgson, G., Alsaffar, A.H., Alhazeen, S.H., 1997a. The Corals and Coral Reef Fishes of Kuwait. Kuwait Institute for Scientific Research, Kuwait.

Carpenter, K.E., Krupp, F., Jones, D., Zajonz, U., 1997b. FAO species identification guide for fishery purposes. The living marine resources of Kuwait, Eastern Saudi Arabia, Bahrain, Qatar, and the United Arab Emirates. FAO, Rome.

Carpenter, K.E., Russell, B., Burt, J., Iwatsuki, Y., 2015a. *Caesio lunaris*. The IUCN Red List of Threatened Species 2015: e.T20249446A57072237. Downloaded 14 March 2016.

Carpenter, K.E., Russell, B., Iwatsuki, Y., Burt, J., 2015b. *Caesio varilineata*. The IUCN Red

List of Threatened Species 2015: e.T20250177A57072329. Downloaded 14 March 2016.

CBD, 2010. COP Decision X/2. Strategic plan for biodiversity 2011–2020. Available at: http://www.cbd.int/decision/ cop/?id=12268. Accessed 2 August 2015.

CBD, 2006a. COP 8 Decision VIII/15. Framework for monitoring implementation of the achievement of the 2010 target and integration of targets into the thematic programmes of work. Available at: http://www.cbd.int/decision/cop/id=11029. Accessed 2 August 2015.

CBD, 2006b. First national report to the convention on biological diversity for the Kingdom of Bahrain. Public Commission for the Protection of Marine Resources, Environment and Wildlife General Directorate for Environment and Wildlife Protection.

Chape, S., Blyth, S., Fish, L., Fox, P., Spalding, M., 2003. 2003 United Nations List of Protected Areas. IUCN: Gland, Switzerland and Cambridge, UK and UNEP-WCMC, Cambridge, UK.

Chapman, M.R., Kramer, D.L., 2000. Movements of fishes within and among finging coral reefs in Barbados. Environ. Biol. Fishes 57, 11–24.

Choat, J.H., Alam, S., Al-Khalaf, K., Al-Kulaifi, A., Burt, J., 2015. *Epinephelus coioides*. The IUCN Red List of Threatened Species 2015: e.T44674A57102119. Downloaded on 10 December 2015.

Clarke, K., Gorley, R., 2006. Primer v6: User Manual/Tutorial. Primer-E, Plymouth.

Coad, B.W., 1992. Marine Fishes of the Persian Gulf and Sea of Oman. Checklist and Bibliography. Syllogeus, Ottawa, M.S.

Coad, L., Leverington, F., Burgess, N.D., Cuadros, I.C., Geldmann, J., Marthews, T.R., Mee, J., Nolte, C., Stoll-kleemann, S., Vansteelant, N., Zamora, C., Hockings, M., 2013. Progress towards the CBD protected area management effectiveness targets. Parks 19, 13–23.

Coles, S.L., 2003. Coral species diversity and environmental factors in the Arabian Gulf and the Gulf of Oman: A comparison to the Indo-Pacific region. Atoll Res. Bull. 1–19.

Coles, S.L., Tarr, A.B., 1990. Reef fish assemblages in the western Arabian Gulf: A geographically isolated population in an extreme environment. Bull. Mar. Sci. 47, 696–720.

Collette, B.B., Smith-Vaniz, W.F., Hartman, S., Bishop, J., Alam, S., Al-Khalaf, K., Alghawzi, Q., Abdulqader, E., Kaymaram, F., Abdallah, M., Al-Binali, A., Almuftah, A., Al-Kulaifi, A., 2015. *Scomberomorus commerson*. The IUCN Red List of Threatened Species 2015: e.T170316A57242652. Downloaded 15 March 2016.

D'Amen, M., Bombi, P., Campanaro, A., Zapponi, L., Bologna, M.A., Mason, F., 2013. Protected areas and insect conservation: Questioning the effectiveness of natura 2000 network for saproxylic beetles in Italy. Anim. Conserv. 16, 370–378. doi:10.1111/acv.12016

Dawoud, M.A., Al-Mulla, M.M., 2012. Environmental Impacts of Seawater Desalination: Arabian Gulf Case Study. Int. J. Environ. Sustain. 1, 22–37.

Dulvy, N.K., Fowler, S.L., Musick, J.A., Cavanagh, R.D., Kyne, P.M., Harrison, L.R., Carlson, J.K., Davidson, L.N.K., Fordham, S. V, Francis, M.P., Pollock, C.M., Simpfendorfer, C.A., Burgess, G.H., Carpenter, K.E., Compagno, L.J. V, Ebert, D.A., Gibson, C., Heupel, M.R., Livingstone, S.R., Sanciangco, J.C., Stevens, J.D., Valenti, S., White, W.T., 2014. Extinction risk and conservation of the world's sharks and rays. Elife 3, 1–35. doi:10.7554/eLife.00590

Dulvy, N.K., Pinnegar, J.K., Reynolds, J.D., 2009. Holocene extinctions in the sea, in: Turvey, S.T. (Ed.), Holocene Extinctions. Oxford University Press, Oxford, pp. 129–150.

Erftemeijer, P.L.A., Shuail, D.A., 2012. Seagrass habitats in the Arabian Gulf: Distribution, tolerance thresholds and threats. Aquat. Ecosyst. Health Manag. 15, 73–83. doi:Aquatic Ecosystem Health & Management, Vol. 15, No. S1, 2012, pp. 73–83

ESRI, 2014. ArcGIS Desktop: Release 10.2.

Feary, D.A., Burt, J.A., Bauman, A.G., Al Hazeem, S., Abdel-Moati, M.A., Al-Khalifa, K.A., Anderson, D.M., Amos, C., Baker, A., Bartholomew, A., Bento, R., Cavalcante, G.H., Chen, C.A., Coles, S.L., Dab, K., Fowler, A.M., George, D., Grandcourt, E., Hill, R., John, D.M., Jones, D.A., Keshavmurthy, S., Mahmoud, H., Moradi Och Tapeh, M., Mostafavi, P.G., Naser, H., Pichon, M., Purkis, S., Riegl, B., Samimi-Namin, K., Sheppard, C., Vajed Samiei, J., Voolstra, C.R., Wiedenmann, J., 2013. Critical research needs for identifying future changes in Gulf coral reef ecosystems. Mar. Pollut. Bull. 72, 406–416. doi:10.1016/j.marpolbul.2013.02.038

Feary, D.A., Burt, J.A., Bauman, A.G., Usseglio, P., Sale, P.F., Cavalcante, G.H., 2010. Fish communities on the world's warmest reefs: What can they tell us about the effects of climate change in the future? J. Fish Biol. 77, 1931–1947. doi:10.1111/j.1095-8649.2010.02777.x

Feary, D.A., Burt, J.A., Calvalcante, G.H., Bauman, A.G., 2012. Extreme Physical Factors and the Structure of Gulf Fish and Reef Communities, in: Riegl, B.M., Purkis, S.J. (Eds.), Coral Reefs of the Gulf: Adaptations to Climatic Extremes. Springer Science+Business Media B. V., pp. 163–170. doi:10.1007/978-94-007-3008-3

Feary, D.A., Pratchett, M.S., J Emslie, M., Fowler, A.M., Figueira, W.F., Luiz, O.J., Nakamura, Y., Booth, D.J., 2014. Latitudinal shifts in coral reef fishes: Why some species do and others do not shift. Fish Fish. 15, 593–615. doi:10.1111/faf.12036

Giri, C., Ochieng, E., Tieszen, L.L., Zhu, Z., Singh, A., Loveland, T., Masek, J., Duke, N., 2011.

Status and distribution of mangrove forests of the world using earth observation satellite data. Glob. Ecol. Biogeogr. 20, 154–159. doi:10.1111/j.1466-8238.2010.00584.x

Grandcourt, E.M., 2012. Reef fish and fisheries in the Gulf, in: Riegl, B.M., Purkis, S.J. (Eds.), Coral Reefs of the Gulf: Adaptations to Climatic Extremes. Springer Science+Business Media B. V., pp. 127–162. doi:10.1007/978-94-007-3008-3

Grandcourt, E.M., 2007a. Corals and Coral Reefs, in: Al Abdessalaam, T.Z. (Ed.), Marine Environment and Resources of Abu Dhabi. Environment Agency - Abu Dhabi (EAD) and Motivate Publishing, Abu Dhabi, pp. 118–161.

Grandcourt, E.M., 2007b. Fish and fisheries, in: Al Abdessalaam, T.Z. (Ed.), Marine Environment and Resources of Abu Dhabi. Environment Agency - Abu Dhabi (EAD) and Motivate Publishing, Abu Dhabi, pp. 200–225.

Grandcourt, E.M., Al Abdessalaam, T.Z., Francis, F., Al Shamsi, A.T., 2005. Population biology and assessment of the orange-spotted grouper, *Epinephelus coioides* (Hamilton, 1822), in the southern Arabian Gulf. Fish. Res. 74, 55–68. doi:10.1016/j.fishres.2005.04.009

Grandcourt, E.M., Al Abdessalaam, T.Z., Francis, F., Al Shamsi, A.T., 2004. Population biology and assessment of representatives of the family Carangidae. Fish. Res. 69, 331–341. doi:10.1016/j.fishres.2004.06.008

Grizzle, R.E., Ward, K.M., AlShihi, R.M.S., Burt, J.A., 2016. Current status of coral reefs in the United Arab Emirates: Distribution, extent, and community structure with implications for management. Mar. Pollut. Bull. 105, 515–523.

Halpern, B.S., Walbridge, S., Selkoe, K.A., Kappel, C. V, Micheli, F., D’Agrosa, C., Bruno, J.F., Casey, K.S., Ebert, C., Fox, H.E., Fujita, R., Heinemann, D., Lenihan, H.S., Madin, E.M.P., Perry, M.T., Selig, E.R., Spalding, M., Steneck, R., Watson, R., 2008. A global map of human impact on marine ecosystems. Science 319, 948–952. doi:10.1126/science.1149345

Harnik, P.G., Lotze, H.K., Anderson, S.C., Finkel, Z.V., Finnegan, S., Lindberg, D.R., Liow, L.H., Lockwood, R., McClain, C.R., McGuire, J.L., O'Dea, A., Pandolfi, J., Simpson, C., Tittensor, D.P., 2012. Extinction in ancient and modern seas. Trends Ecol. Evol. 27, 608–617.

Hoffmann, M., Hilton-Taylor, C., Angulo, A., Böhm, M., Brooks, T.M., Butchart, S.H.M., Carpenter, K.E., Chanson, J., Collen, B., Cox, N.A., Darwall, W.R.T., Dulvy, N.K., Harrison, L.R., Katariya, V., Pollock, C.M., Quader, S., Richman, N.I., Rodrigues, A.S.L., Tognelli, M.F., Vié, J.-C., Aguiar, J.M., Allen, D.J., Allen, G.R., Amori, G., Ananjeva, N.B., Andreone, F., Andrew, P., Aquino Ortiz, A.L., Baillie, J.E.M., Baldi, R., Bell, B.D., Biju, S.D., Bird, J.P., Black-Decima, P., Blanc, J.J., Bolaños, F., Bolivar-G, W., Burfield, I.J., Burton, J.A., Capper, D.R., Castro, F., Catullo, G., Cavanagh, R.D., Channing, A., Chao, N.L., Chenery, A.M., Chiozza, F., Clausnitzer, V., Collar, N.J., Collett, L.C., Collette, B.B., Cortez Fernandez, C.F., Craig, M.T., Crosby, M.J., Cumberlidge, N., Cuttelod, A., Derocher, A.E., Diesmos, A.C., Donaldson, J.S., Duckworth, J.W., Dutson, G., Dutta, S.K., Emslie, R.H., Farjon, A., Fowler, S., Freyhof, J., Garshelis, D.L., Gerlach, J., Gower, D.J., Grant, T.D., Hammerson, G.A., Harris, R.B., Heaney, L.R., Hedges, S.B., Hero, J.-M., Hughes, B., Hussain, S.A., Icochea M, J., Inger, R.F., Ishii, N., Iskandar, D.T., Jenkins, R.K.B., Kaneko, Y., Kottelat, M., Kovacs, K.M., Kuzmin, S.L., La Marca, E., Lamoreux, J.F., Lau, M.W.N., Lavilla, E.O., Leus, K., Lewison, R.L., Lichtenstein, G., Livingstone, S.R., Lukoschek, V., Mallon, D.P., McGowan, P.J.K., McIvor, A., Moehlman, P.D., Molur, S., Muñoz Alonso, A., Musick, J.A., Nowell, K., Nussbaum, R.A., Olech, W., Orlov, N.L., Papenfuss, T.J., Parra-Olea, G., Perrin, W.F., Polidoro, B.A., Pourkazemi, M., Racey, P.A., Ragle, J.S., Ram, M., Rathbun, G., Reynolds, R.P., Rhodin, A.G.J., Richards, S.J., Rodríguez, L.O., Ron, S.R., Rondinini, C., Rylands, A.B., Sadovy de Mitcheson, Y., Sanciangco, J.C., Sanders, K.L., Santos-Barrera, G., Schipper, J., Self-Sullivan, C., Shi, Y., Shoemaker, A., Short, F.T., Sillero-Zubiri, C., Silvano, D.L., Smith, K.G., Smith, A.T., Snoeks, J., Stattersfield, A.J., Symes, A.J., Taber, A.B., Talukdar, B.K., Temple, H.J., Timmins, R., Tobias, J.A., Tsytsulina, K., Tweddle, D., Ubeda, C., Valenti, S. V, van Dijk, P.P., Veiga, L.M., Veloso, A., Wege, D.C., Wilkinson, M., Williamson, E.A., Xie, F., Young, B.E., Akçakaya, H.R., Bennun, L., Blackburn, T.M., Boitani, L., Dublin, H.T., da Fonseca, G.A.B., Gascon, C., Lacher, T.E., Mace, G.M., Mainka, S.A., McNeely, J.A., Mittermeier, R.A., Reid, G.M., Rodriguez, J.P., Rosenberg, A.A., Samways, M.J., Smart, J., Stein, B.A., Stuart, S.N., 2010. The impact of conservation on the status of the world's vertebrates. Science (80-.). 330, 1503–1509. doi:10.1126/science.1194442

Höpner, T., Lattemann, S., 2002. Chemical impacts from seawater desalination plants — a case study of the northern Red Sea. Desalination 152, 133–140. doi:10.1016/S0011-9164(02)01056-1

IUCN, 2012a. IUCN Red List Categories and Criteria: Version 3.1, Second Edi. ed, IUCN. IUCN, Gland, Switzerland and Cambridge, UK. doi:10.9782-8317-0633-5

IUCN, 2012b. Guidelines for Application of IUCN Red List Criteria at Regional and National Levels: Version 4.0. IUCN, Gland, Switzerland and Cambridge, UK.

IUCN, 2011. Guidelines for Appropriate Uses of IUCN Red List Data. Incorporating the Guidelines for Reporting on Proportion Threatened and the Guidelines on Scientific Collecting of Threatened Species. Version 2. Adopted by the IUCN Red List Committee and IUCN Steering Committee.

IUCN and UNEP-WCMC, 2015. The World Database on Protected Areas (WDPA) [Online], July/2015, Cambridge, UK: UNEP-WCMC. Available at: www.protectedplanet.net [WWW Document].

Iwatsuki, Y., Carpenter, K.E., 2009. *Acanthopagrus randalli* (Perciformes: Sparidae), a new black seabream from the Persian Gulf. Zootaxa 2267, 43–54.

Iwatsuki, Y., Carpenter, K.E., Russell, B., Abdulqader, E., Kaymaram, F., Bishop, J., Hartmann, S., Alam, S., Al-Khalaf, K., Jassim Kawari, A., Alghawzi, Q., 2015. *Lutjanus malabaricus*. The IUCN Red List of Threatened Species 2015: e.T194346A57148327. Downloaded on 1 March 2016.

Jenkins, C.N., Joppa, L., 2009. Expansion of the global terrestrial protected area system. Biol. Conserv. 142, 2166–2174. doi:10.1016/j.biocon.2009.04.016

Khan, N.Y., 2007. Multiple stressors and ecosystem-based management in the Gulf. Aquat. Ecosyst. Health Manag. 10, 259–267. doi:10.1080/14634980701551168

King, H., 2002. The Hawar Archipelago [WWW Document]. URL http://www.hawar-islands.com/Hawar_application.htm

Klein, C.J., Brown, C.J., Halpern, B.S., Segan, D.B., McGowan, J., Beger, M., Watson, J.E.M., 2015. Shortfalls in the global protected area network at representing marine biodiversity. Sci. Rep. 5, 17539. doi:10.1038/srep17539

Krupp, F., 2002. Marine protected areas, in: Khan, M.Y., Munawar, M., Price, A.R.G. (Eds.), The Gulf Ecosystem Health and Sustainability. Backhuys, pp. 447–473.

Krupp, F. (Ed), 2008. Transboundary Diagnostic Analysis. Final Report Phase 1. UNESCO, ROPME and Senkenenberg Research Institute, 122 pp.

Krupp, F., Al-Muftah, A., Jones, D.A., Hoolihan, J., 2006. Marine and coastal ecosystem management requirements in the Arabian Peninsula with special regard to water resources - Policy Perspectives for Ecosystem and Water Management in the Arabian Peninsula. UNESCO Doha and United Nations University, Hamilton, Ontario, pp. 73-87.

Krupp, F., Khalaf, M., Malek, M., Streit, B., Al-Jumaily, M., 2009. The Middle Eastern Biodiversity Network: Generating and sharing knowledge for ecosystem management and conservation. Zookeys 31, 3–15. doi:10.3897/zookeys.31.371

Krupp, F., Khushaim, O., 1996. The Jubail Marine Wildlife Sanctuary., in: Krupp, F., Abuzinada, A.H., Nader, I.A. (Eds.), A Marine Wildlife Sanctuary for the Arabian Gulf: Environmental Research and Conservation Following the 1991 Gulf War Oil Spill. NCWCD, Riyadh and Senckenberg Research Institute, Frankfurt a.M., pp. 17–32.

Krupp, F., Müller, T., 1994. The status of fish populations in the northern Arabian Gulf two years after the 1991 Gulf War oil spill. Cour. Forschungsinstitut Senckenb. 166, 67–75.

Kujala, H., Araújo, M.B., Thuiller, W., Cabeza, M., 2011. Misleading results from conventional gap analysis - Messages from the warming north. Biol. Conserv. 144, 2450–2458. doi:10.1016/j.biocon.2011.06.023

Langhammer, P.F., Bakarr, M.I., Bennun, L.A., Brooks, T.M., Clay, R.P., Darwall, W., De Silva, N., Edgar, G.J., Eken, G., Fishpool, L.D.C., da Fonseca, G.A.B., Foster, M.N., Knox, D.H., Matiku, P., Radford, E.A., Rodrigues, A.S.L., Salaman, P., Sechrest, W., Tordoff, A.W., 2007. Identification and gap analysis of key biodiversity areas: targets for comprehensive protected area systems. Gland, Switzerland: IUCN.

Larson, H., Williams, J.T., Burt, J.A., Allen, G.R., 2015. *Gobiodon citrinus*. IUCN Red List Threat. Species 2015. e.T193106A57110511. Downloaded 12 December 2015.

Lattemann, S., Höpner, T., 2008. Environmental impact and impact assessment of seawater desalination. Desalination 220, 1–15. doi:10.1016/j.desal.2007.03.009

Literathy, P., 1993. Considerations for the assessement of environmental consequences of the 1991 Gulf War. Mar. Pollut. Bull. 27, 349–356. doi:10.1016/0025-326X(93)90042-I

Mace, G.M., Collar, N.J., Gaston, K.J., Hilton-Taylor, C., Akçakaya, H.R., Leader-Williams, N., Milner-Gulland, E.J., Stuart, S.N., 2008. Quantification of extinction risk: IUCN's system for classifying threatened species. Conserv. Biol. 22, 1424–1442. doi:10.1111/j.1523-1739.2008.01044.x

Malak, D.A., Livingstone, S.R., Pollard, D., Polidoro, B.A., Cuttelod, A., Bariche, M., Bilecenoglu, M., Carpenter, K.E., Collette, B.B., Francour, P., Goren, M., Kara, M.H., Massuti, E., Papaconstantinou, C., Tunesi, L., 2011. Overview of the Conservation Status of the Marine Fishes of the Mediterranean Sea. Gland, Switzerland and Malaga, Spain:IUCN.

Margules, C.R., Pressey, R.L., 2000. Systematic conservation planning. Nature 405, 243–253. doi:10.1038/35012251

Mazaris, A.D., Almpanidou, V., Wallace, B.P., Pantis, J.D., Schofield, G., 2014. A global gap analysis of sea turtle protection coverage. Biol. Conserv. 173, 17–23. doi:10.1016/j.biocon.2014.03.005

Morgan, G.R., 2006. Subregional review: Northwest Indian Ocean. In: De Young C (ed) Review of the state of world marine capture fisheries management: Indian Ocean. FAO Fisheries Technical Paper 488, Food and Agricultural Organization of the United Nations, Rome, pp 51-66.

Naser, H., 2011. Human Impacts on Marine Biodiversity: Macrobenthos in Bahrain, Arabian Gulf, in: Lopez-Pujol, J. (Ed.), The Importance of Biological Interactions in the Study of Biodiversity. InTech, Rijeka, Croatia, pp. 109–126.

Naser, H.A., 2014. Marine Ecosystem Diversity in the Arabian Gulf: Threats and Conservation, in: Biodiversity: The Dynamic Balance of the Planet.

Nash, K.L., Welsh, J.Q., Graham, N.A.J., Bellwood, D.R., 2015. Home-range allometry in coral reef fishes: Comparison to other vertebrates, methodological issues and management implications. Oecologia 177, 73–83. doi:10.1007/s00442-014-3152-y

Nieto, A., Ralph, G.M., Comeros-Raynal, M.T., Kemp, J., Criado, M.G., Allen, D.J., Dulvy, N.K., Walls, R.H.L., Russell, B., Pollard, D., Garcia, S., Craig, M., Collette, B.B., Pollom, R., Biscoito, M., Chao, N.L., Abella, A., Afonso, P., Alvarez, H., Carpenter, K.E., Clo, S., Cook, R., Costa, M.J., Delgado, J., Dureuil, M., Ellis, J.R., Farrell, E.D., Fernandez, P., Florin, A.-B., Fordham, S., Fowler, S., de Sola, L.G., Herrera, J.G., Goodpaster, A., Harvey, M., Heessen, H., Herler, J., Jung, A., Karmovskaya, E., Keskin, C., Knudsen, S.W., Kobyliansky, S., Kovacic, M., Lawson, J.M., Lorance, P., Phillips, S.M., Munroe, T., Nedreaas, K., Nielsen, J., Papaconstantinou, C., Polidoro, B., Pollock, C.M., Rijnsdorp, A.D., Sayer, C., Scott, J., Serena, F., Smith-Vaniz, W.F., Soldo, A., Stump, E., Williams, J.T., 2015. European Red List of Marine Fishes. Belgium.

Pimm, S.L., Jenkins, C.N., Abell, R., Brooks, T.M., Gittleman, J.L., Joppa, L.N., Raven, P.H., Roberts, C.M., Sexton, J.O., 2014. The biodiversity of species and their rates of extinction, distribution, and protection. Science (80-.). 344, 1246752. doi:10.1126/science.1246752

Pimm, S.L., Russell, G.J., Gittleman, J.L., Brooks, T.M., 1995. The future of biodiversity. Science (80-.). 269, 347–350. doi:10.1126/science.269.5222.347

Polidoro, B.A., Brooks, T., Carpenter, K.E., Edgar, G.J., Henderson, S., Sanciangco, J., Robertson, D.R., 2012. Patterns of extinction risk and threat for marine vertebrates and habitat-forming species in the Tropical Eastern Pacific. Mar. Ecol. Prog. Ser. 448, 93–104.

doi:10.3354/meps09545

Polidoro, B.A., Carpenter, K.E., Collins, L., Duke, N.C., Ellison, A.M., Ellison, J.C., Farnsworth, E.J., Fernando, E.S., Kathiresan, K., Koedam, N.E., Livingstone, S.R., Miyagi, T., Moore, G.E., Nam, V.N., Ong, J.E., Primavera, J.H., Salmo, S.G., Sanciangco, J.C., Sukardjo, S., Wang, Y., Yong, J.W.H., 2010. The loss of species: Mangrove extinction risk and geographic areas of global concern. PLoS One 5. doi:10.1371/journal.pone.0010095

Polidoro, B.A., Livingstone, S.R., Carpenter, K.E., Hutchinson, B., Mast, R.B., Pilcher, N., Sadovy de Mitcheson, Y., Valenti, S., 2009. Status of the world's marine species, in: Vié, J.-C., Hilton-Taylor, C., Stuart, S.N. (Eds.), Wildlife in a Changing World. Island Press, IUCN Gland, Switzerland.

Possingham, H.P., Wilson, K.A., Andelman, S.J., Vynne, C.H., 2006. Protected areas: Goals, limitations, and design, in: Groom, M.J., Meffe, G.K., Carroll, C.R. (Eds.), Principles of Conservation Biology. Sinauer Associates, Sunderland, Massachusetts, p. 43.

Price, A.R.G., Sheppard, C.R.C., Roberts, C.M., 1993. The Gulf: Its Biological Setting. Mar. Pollut. Bull. 27, 9–15. doi:10.1016/0025-326X(93)90004-4

Purkis, S.J., Riegl, B.M., 2012. Geomorphology and reef building in the SE Gulf, in: Riegl, B.M., Purkis, S.J. (Eds.), Coral Reefs of the Gulf: Adaptations to Climatic Extremes. Springer Science+Business Media B. V., pp. 33–50.

Randall, J.E., 1995. Coastal fishes of Oman. University of Hawaii Press, Honolulu, Hawaii.

Reynolds, R.M., 1993. Physical oceanography of the Gulf, Strait of Hormuz, and the Gulf of Oman—Results from the Mt Mitchell expedition. Mar. Pollut. Bull. 1–49.

Rezai, H., Wilson, S., Claereboudt, M., Riegl, B., 2004. Coral reef status in ROPME Sea area, in: Wilkinson, C.R. (Ed.), Status of Coral Reefs of the World. Australian Institute of Marine

Science, Townsville, pp. 155–170.

Riegl, B., 2002. Effects of the 1996 and 1998 positive sea-surface temperature anomalies on corals, coral diseases and fish in the Arabian Gulf (Dubai, UAE). Mar. Biol. 140, 29–40. doi:10.1007/s002270100676

Riegl, B., Purkis, S., 2015. Coral population dynamics across consecutive mass mortality events. Glob. Chang. Biol. 21, 3995–4005. doi:10.1111/gcb.13014

Riegl, B.M., Purkis, S.J., 2012. Dynamics of Gulf coral communities: Observations and models from the world's hottest coral sea, in: Riegl, B.M., Purkis, S.J. (Eds.), Coral Reefs of the Gulf: Adaptations to Climatic Extremes. Springer Science+Business Media B. V., pp. 71–94.

Roberts, C.M., Hawkins, J.P., 1999. Extinction risk in the sea. Trends Ecol. Evol. 14, 241–246.

Rodrigues, A.S.L., Akçakaya, H.R., Andelman, S.J., Bakarr, M.I., Boitani, L., Brooks, T.M., Chanson, J.S., Fishpool, L.D.C., da Fonseca, G.A.B., Gaston, K.J., Hoffmann, M., Marquet, P.A., Pilgrim, J.D., Pressey, R.L., Schipper, J., Sechrest, W., Stuart, S.N., Underhill, L.G., Waller, R.W., Matthew, E.J., 2004a. Global Gap Analysis : Priority Regions for Expanding the Global Protected-Area Network. Bioscience 54, 1092–1100.

Rodrigues, A.S.L., Andelman, S.J., Bakarr, M.I., Boitani, L., Brooks, T.M., Cowling, R.M., Fishpool, L.D.C., da Fonseca, G.A.B., Gaston, K.J., Hoffmann, M., Long, J.S., Marquet, P.A., Pilgrim, J.D., Pressey, R.L., Schipper, J., Sechrest, W., Stuart, S.N., Underhill, L.G., Waller, R.W., Watts, M.E.J., Yan, X., 2004b. Effectiveness of the global protected area network in representing species diversity. Nature 428, 640–643. doi:10.1038/nature02459.1.

Sale, P.F., Feary, D.A., Burt, J.A., Bauman, A.G., Cavalcante, G.H., Drouillard, K.G., Kjerfve, B., Marquis, E., Trick, C.G., Usseglio, P., Van Lavieren, H., 2011. The Growing Need for

Sustainable Ecological Management of Marine Communities of the Persian Gulf. Ambio 40, 4–17. doi:10.1007/s13280-010-0092-6

Samuel, M., Mathews, C.P., Baddar, M.K., 1987. Stock assessment of hamrah (*Lutjanus coccineus*) and Hamoor (*Epinephelus tauvina*) from the Arabian Gulf using surplus production and dynamic pool models. Kuwait Bull. Mar. Sci. 9, 195–206.

Schipper, J., Chanson, J.S., Chiozza, F., Cox, N.A., Hoffmann, M., Katariya, V., Lamoreux, J., Rodrigues, A.S.L., Stuart, S.N., Temple, H.J., Baillie, J., Boitani, L., Lacher, T.E., Mittermeier, R.A., Smith, A.T., Absolon, D., Aguiar, J.M., Amori, G., Bakkour, N., Baldi, R., Berridge, R.J., Bielby, J., Black, P.A., Blanc, J.J., Brooks, T.M., Burton, J.A., Butynski, T.M., Catullo, G., Chapman, R., Cokeliss, Z., Collen, B., Conroy, J., Cooke, J.G., da Fonseca, G.A.B., Derocher, A.E., Dublin, H.T., Duckworth, J.W., Emmons, L., Emslie, R.H., Festa-Bianchet, M., Foster, M., Foster, S., Garshelis, D.L., Gates, C., Gimenez-Dixon, M., Gonzalez, S., Gonzalez-Maya, J.F., Good, T.C., Hammerson, G., Hammond, P.S., Happold, D., Happold, M., Hare, J., Harris, R.B., Hawkins, C.E., Haywood, M., Heaney, L.R., Hedges, S., Helgen, K.M., Hilton-Taylor, C., Hussain, S.A., Ishii, N., Jefferson, T.A., Jenkins, R.K.B., Johnston, C.H., Keith, M., Kingdon, J., Knox, D.H., Kovacs, K.M., Langhammer, P., Leus, K., Lewison, R., Lichtenstein, G., Lowry, L.F., Macavoy, Z., Mace, G.M., Mallon, D.P., Masi, M., McKnight, M.W., Medellín, R.A., Medici, P., Mills, G., Moehlman, P.D., Molur, S., Mora, A., Nowell, K., Oates, J.F., Olech, W., Oliver, W.R.L., Oprea, M., Patterson, B.D., Perrin, W.F., Polidoro, B.A., Pollock, C., Powel, A., Protas, Y., Racey, P., Ragle, J., Ramani, P., Rathbun, G., Reeves, R.R., Reilly, S.B., Reynolds, J.E., Rondinini, C., Rosell-Ambal, R.G., Rulli, M., Rylands, A.B., Savini, S., Schank, C.J., Sechrest, W., Self-Sullivan, C., Shoemaker, A., Sillero-Zubiri, C., De Silva, N., Smith, D.E., Srinivasulu, C., Stephenson, P.J., van Strien, N., Talukdar, B.K., Taylor, B.L., Timmins, R., Tirira, D.G., Tognelli, M.F., Tsytsulina, K., Veiga, L.M., Vié, J.-C., Williamson, E.A., Wyatt, S.A., Xie, Y., Young, B.E., 2008. The status of the world's land and marine mammals: diversity, threat, and knowledge. Science (80-.). 322, 225–230. doi:10.1126/science.1165115

Scott, J.M., Davis, F., Csuti, B., Noss, R., Butterfield, B., Groves, C., Anderson, H., Caicco, S., Erchia, F.D., Edwards, T.C., Ulliman, J., Gerald, R., Anderson, H., Caicco, S., D'Erchia, F., Edwards, T.C., Ulliman, J., Wright, G.R., 1993. Gap Analysis: A geographic approach to protection of biological diversity. Wildl. Monogr. 3–41.

Sheppard, C., 2016. Coral reefs in the Gulf are mostly dead now, but can we do anything about it? Mar. Pollut. Bull. 105, 593–598. doi:10.1016/j.marpolbul.2015.09.031

Sheppard, C., Al-Husaini, M., Al-Jamali, F., Al-Yamani, F., Baldwin, R., Bishop, J., Benzoni, F., Dutrieux, E., Dulvy, N.K., Durvasula, S.R. V., Jones, D.A., Loughland, R., Medio, D., Nithyanandan, M., Pilling, G.M., Polikarpov, I., Price, A.R.G., Purkis, S.J., Riegl, B.M., Saburova, M., Samimi-Namin, K., Taylor, O., Wilson, S., Zainal, K., 2012. Environmental concerns for the future of Gulf coral reefs, in: Riegl, B.M., Purkis, S.J. (Eds.), Coral Reefs of the Gulf: Adaptations to Climatic Extremes. Springer Science+Business Media B. V., pp. 349–373.

Sheppard, C., Al-Husiani, M., Al-Jamali, F., Al-Yamani, F., Baldwin, R., Bishop, J., Benzoni, F., Dutrieux, E., Dulvy, N.K., Durvasula, S.R. V., Jones, D.A., Loughland, R., Medio, D., Nithyanandan, M., Pilling, G.M., Polikarpov, I., Price, A.R.G., Purkis, S., Riegl, B., Saburova, M., Namin, K.S., Taylor, O., Wilson, S., Zainal, K., 2010. The Gulf: A young sea in decline. Mar. Pollut. Bull. 60, 13–38. doi:10.1016/j.marpolbul.2009.10.017

Sheppard, C., Price, A., Roberts, C., 1992. Marine Ecology of the Arabian Region: Patterns and Processes in Extreme Tropical Environments. Academic Press, London.

Short, F.T., Polidoro, B., Livingstone, S.R., Carpenter, K.E., Bandeira, S., Bujang, J.S., Calumpong, H.P., Carruthers, T.J.B., Coles, R.G., Dennison, W.C., Erftemeijer, P.L.A., Fortes, M.D., Freeman, A.S., Jagtap, T.G., Kamal, A.H.M., Kendrick, G.A., Judson Kenworthy, W., La Nafie, Y.A., Nasution, I.M., Orth, R.J., Prathep, A., Sanciangco, J.C., Tussenbroek, B. Van, Vergara, S.G., Waycott, M., Zieman, J.C., 2011. Extinction risk assessment of the world's seagrass species. Biol. Conserv. 144, 1961–1971. doi:10.1016/j.biocon.2011.04.010

Shulman, M.J., 1985. Recruitment of Coral Reef Fishes: Effects of Distribution of Predators and Shelter. Ecology 66, 1056–1066.

Smith-Vaniz, W.F., Collette, B.B., Abdulqader, E., Kaymaram, F., Bishop, J., Alghawzi, Q., Hartmann, S., 2015. *Gnathanodon speciosus*. The IUCN Red List of Threatened Species 2015: e.T20432145A58572650. Downloaded on 1 March 2016.

Soulé, M.E., 1987. Viable populations for conservation. Cambridge University Press, Cambridge.

Spalding, M.D., Kainuma, M., Collins, L., 2010. World Atlas of Mangroves. London: Earthscan, with International Society for Mangrove Ecosystems, Food and Agriculture Organization of the United Nations, UNEP World Conservation Monitoring Centre, United Nations Scientific and Cultural Organisation, and United Nations University.

Subcommittee, I.S. and P., 2014. Guidelines for Using the IUCN Red List Categories and Criteria. Version 11. Prepared by the Standards and Petitions Subcommittee.

Sweatman, H., Robertson, D.R., 1994. Grazing halos and predation on juvenile Caribbean surgeonfishes. Mar. Ecol. Prog. Ser. 111, 1–6.

Turgeon, K., Robillard, A., Grégoire, J., Duclos, V., Kramer, D.L., 2010. Functional connectivity from a reef fish perspective: Behavioral tactics for moving in a fragmented landscape. Ecology 91, 3332–3342.

Uiblein, F., Heemstra, P.C., 2011. Description of a new goatfish species, *Upeneus randalli* n. sp.(Mullidae), from the Persian Gulf, with remarks and identification keys for the genus *Upeneus*. Sci. Mar. 75, 585–594. doi:10.3989/scimar.2011.75n3585

UNEP, 2002. Report on the sixth meeting of the Conference of the Parties to the Convention on Biological Diversity (UNEP/CBD/COP/20/Part 2) Strategic Plan Decision VI/26 in CBD. Nairobi.

UNEP-WCMC, Short, F.T., 2005. Global distribution of seagrasses (version 3.0). Third update to the data layer used in Green and Short (2003). Cambridge (UK): UNEP World Conservation Monitoring Centre. URL: http://data.unepwcmc.org/datasets/7.

UNEP-WCMC, Worldfish-Centre, WRI, TNC, 2010. Global distribution of warm-water coral reefs, compiled from multiple sources including the Millennium Coral Reef Mapping Project. Includes contributions from IMaRS-USF and IRD (2005), IMaRS-USF (2005) and Spalding et al. (2001) Cambridge (UK): UNEP World.

Van Lavieren, H., Burt, J., Feary, D.A., Cavalcante, Geórgenes Marquis, E., Benedetti, L., Trick, C., Kjerfve, B., Sale, P.F., 2011. Managing the growing impacts of development on fragile coastal and marine ecosystems: Lessons from the Gulf. A policy report. Hamilton, ON, Canada.

Van Lavieren, H., Klaus, R., 2013. An effective regional Marine Protected Area network for the ROPME Sea Area: unrealistic vision or realistic possibility? Mar. Pollut. Bull. 72, 389–405.

doi:10.1016/j.marpolbul.2012.09.004

Vaughan, G.O., Burt, J.A., 2016. The changing dynamics of coral reef science in Arabia. Mar. Pollut. Bull. 105, 441–458. doi:10.1016/j.marpolbul.2015.10.052

Venter, O., Fuller, R.A., Segan, D.B., Carwardine, J., Brooks, T., Butchart, S.H.M., Di Marco, M., Iwamura, T., Joseph, L., O'Grady, D., Possingham, H.P., Rondinini, C., Smith, R.J., Venter, M., Watson, J.E.M., 2014. Targeting Global Protected Area Expansion for Imperiled Biodiversity. PLoS Biol. 12, 10.1371/journal.pbio.1001891. doi:10.1371/journal.pbio.1001891

Visconti, P., Di Marco, M., Álvarez-Romero, J.G., Januchowski-Hartley, S.R., Pressey, R.L., Weeks, R., Rondinini, C., 2013. Effects of errors and gaps in spatial data sets on assessment of conservation progress. Conserv. Biol. 27, 1000–1010. doi:10.1111/cobi.12095

Welsh, J.Q., Bellwood, D.R., 2012. Spatial ecology of the steephead parrotfish (*Chlorurus microrhinos*): An evaluation using acoustic telemetry. Coral Reefs 31, 55–65. doi:10.1007/s00338-011-0813-8

Williams, J.T., Burt, J.A., Allen, G., Larson, H.K., 2015. *Alticus kirkii*. The IUCN Red List of Threatened Species 2015: e.T46079096A56997214. Downloaded on 1 March 2016.

Zainal, A.J.M., Dalby, D.H., Robinson, I.S., 1993. Monitoring marine ecological changes on the east coast of Bahrain with Landsat TM. Photogramm. Eng. Remote Sens. 59, 415–421.

APPENDIX A

TABLE SI: LIST OF MARINE BONY FISHES WITH UNCONFIRMED RANGES WITHIN THE GULF.

Order	Family	Species
Clupeiformes	Engraulidae	*Stolephorus insularis*
Clupeiformes	Engraulidae	*Thryssa baelama*
Perciformes	Apogonidae	*Ostorhinchus cookii*
Perciformes	Callionymidae	*Callionymus sagitta*
Perciformes	Epinephelidae	*Anyperodon leucogrammicus*
Perciformes	Kyphosidae	*Kyphosus bigibbus*
Perciformes	Kyphosidae	*Kyphosus cinerascens*
Perciformes	Kyphosidae	*Kyphosus sectatrix*
Perciformes	Kyphosidae	*Kyphosus vaigiensis*
Perciformes	Labridae	*Scarus fuscopurpureus*
Perciformes	Lutjanidae	*Lutjanus johnii*
Perciformes	Sciaenidae	*Argyrosomus amoyensis*
Perciformes	Siganidae	*Siganus rivulatus*
Scorpaeniformes	Scorpaenidae	*Scorpaenopsis venosa*
Scorpaeniformes	Synanceiidae	*Minous inermis*

APPENDIX B

TABLE SII: LIST OF NATIONALLY, DESIGNATED PROTECTED AREAS INCLUDED IN ANALYSES, WITH INFORMATION REGARDING EDITS MADE TO DATA.

Country	Protected Area	Data Source	Data Modifications
Bahrain	Dohat Arad (Arab Bay)	WDPA (Point)	Replaced with buffered centroid equivalent to its known total area
Bahrain	Fasht Bulthama (Reef Bul Thamah)	WDPA (Point)	Replaced with buffered centroid equivalent to its known total area
Bahrain	Hawar Islands	http://www.hawar-islands.com/Hawar_application.htm	Created protected area polygon boundaries using coordinates attained from data source.
Bahrain	Mashtan Island	WDPA (Point)	Replaced with buffered centroid equivalent to its known total area
Bahrain	Tubli Bay	WDPA (Point)	Replaced with buffered centroid equivalent to its known total area
Iran	Faror (Farur Island)	WDPA (Polygon)	No alterations made
Iran	Hara	WDPA (Polygon)	No alterations made
Iran	Hara-e Khoran	WDPA (Polygon)	No alterations made
Iran	Heleh	WDPA (Polygon)	No alterations made
Iran	Kharko (Kharku Island)	WDPA (Polygon)	No alterations made
Iran	Mond	WDPA (Polygon)	No alterations made
Iran	Nayband	WDPA (Polygon)	No alterations made
Iran	Shadegan	WDPA (Polygon)	No alterations made
Iran	Shidvar	WDPA (Polygon)	No alterations made
Iraq	Khor Al-Zubair	WDPA (Polygon)	No alterations made
Kuwait	Al-Doha Reserve	WDPA (Polygon)	No alterations made
Kuwait	Al-Sulaibikhat	WDPA (Polygon)	No alterations made
Kuwait	Jahra	WDPA (Polygon)	No alterations made
Kuwait	Mubarak Al-Kabeer	WDPA (Polygon)	No alterations made
Kuwait	Om Neqa	WDPA (Polygon)	No alterations made
Kuwait	Sabah Al-Ahmad	WDPA (Polygon)	No alterations made

Country	Protected Area	Data Source	Data Modifications
Qatar	Khor Al Adaid	WDPA (Point)	Replaced with buffered centroid equivalent to its known total area
Saudi Arabia	Al-‘Uruq al-Mu‘taridah	WDPA (Polygon)	No alterations made
Saudi Arabia	Jubail Marine Wildlife Sanctuary (Abu Ali/Dawhat and Dafi Musallamiyah complex)	Krupp et al. 1995	Created protected area polygon boundaries using coordinates attained from data source.
United Arab Emirates	Al Yasat	WDPA (Polygon)	No alterations made
United Arab Emirates	Bul Syayeef	WDPA (Polygon)	No alterations made
United Arab Emirates	Houbara	WDPA (Polygon)	No alterations made
United Arab Emirates	Jabal/Jebel Ali	WDPA (Point)	Replaced with buffered centroid equivalent to its known total area
United Arab Emirates	Marawah	WDPA (Polygon)	No alterations made
United Arab Emirates	Ras Al Khawr	WDPA (Point)	Replaced with buffered centroid equivalent to its known total area

APPENDIX C

TABLE SIII: THE LIST OF THE MARINE BONY FISHES OF THE GULF. EACH SPECIES' REGIONAL CONSERVATION STATUS AND LEVEL OF ENDEMISM IN THE GULF ARE ALSO PROVIDED. IUCN RED LIST CATEGORIES ARE ABBREVIATED AS FOLLOWS: DATA DEFICIENT (DD), LEAST CONCERN (LC), NEAR THREATENED (NT), VULNERABLE (VU), ENDANGERED (EN).

Order	Family	Species	IUCN Red List Category	IUCN Red List Criteria*	Endemic to the Gulf
Anguilliformes	Muraenesocidae	*Muraenesox cinereus*	DD		No
Anguilliformes	Muraenidae	*Gymnomuraena zebra*	LC		No
Anguilliformes	Muraenidae	*Gymnothorax herrei*	DD		No
Anguilliformes	Muraenidae	*Gymnothorax undulatus*	LC		No
Anguilliformes	Ophichthidae	*Brachysomophis cirrocheilos*	DD		No
Anguilliformes	Ophichthidae	*Muraenichthys schultzei*	DD		No
Atheriniformes	Atherinidae	*Atherinomorus lacunosus*	LC		No
Atheriniformes	Atherinidae	*Hypoatherina temminckii*	LC		No
Aulopiformes	Synodontidae	*Saurida tumbil*	LC		No
Aulopiformes	Synodontidae	*Saurida undosquamis*	DD		No
Aulopiformes	Synodontidae	*Trachinocephalus myops*	DD		No
Batrachoidiformes	Batrachoididae	*Colletteichthys dussumieri*	LC		No
Batrachoidiformes	Batrachoididae	*Colletteichthys occidentalis*	LC		No
Beloniformes	Belonidae	*Ablennes hians*	LC		No
Beloniformes	Belonidae	*Platybelone argalus*	LC		No
Beloniformes	Belonidae	*Strongylura leiura*	LC		No
Beloniformes	Belonidae	*Strongylura strongylura*	LC		No
Beloniformes	Belonidae	*Tylosurus choram*	LC		No
Beloniformes	Belonidae	*Tylosurus crocodilus*	LC		No
Beloniformes	Exocoetidae	*Cypselurus oligolepis*	LC		No
Beloniformes	Exocoetidae	*Parexocoetus mento*	LC		No
Beloniformes	Hemiramphidae	*Hemiramphus marginatus*	LC		No
Beloniformes	Hemiramphidae	*Hyporhamphus limbatus*	LC		No
Beloniformes	Hemiramphidae	*Hyporhamphus sindensis*	LC		No
Beloniformes	Hemiramphidae	*Hyporhamphus unicuspis*	DD		No
Beloniformes	Hemiramphidae	*Rhynchorhamphus georgii*	LC		No
Beryciformes	Monocentridae	*Monocentris japonica*	DD		No
Clupeiformes	Chirocentridae	*Chirocentrus dorab*	LC		No
Clupeiformes	Chirocentridae	*Chirocentrus nudus*	LC		No
Clupeiformes	Clupeidae	*Anodontostoma chacunda*	LC		No

Order	Family	Species	IUCN Red List Category	IUCN Red List Criteria*	Endemic to the Gulf
Clupeiformes	Clupeidae	*Dussumieria acuta*	LC		No
Clupeiformes	Clupeidae	*Dussumieria elopsoides*	LC		No
Clupeiformes	Clupeidae	*Herklotsichthys lossei*	DD		No
Clupeiformes	Clupeidae	*Nematalosa nasus*	LC		No
Clupeiformes	Clupeidae	*Nematalosa persara*	DD		No
Clupeiformes	Clupeidae	*Nematalosa resticularia*	DD		No
Clupeiformes	Clupeidae	*Sardinella albella*	LC		No
Clupeiformes	Clupeidae	*Sardinella gibbosa*	LC		No
Clupeiformes	Clupeidae	*Sardinella longiceps*	LC		No
Clupeiformes	Clupeidae	*Sardinella sindensis*	LC		No
Clupeiformes	Clupeidae	*Tenualosa ilisha*	NT		No
Clupeiformes	Engraulidae	*Encrasicholina devisi*	LC		No
Clupeiformes	Engraulidae	*Encrasicholina heteroloba*	DD		No
Clupeiformes	Engraulidae	*Encrasicholina punctifer*	LC		No
Clupeiformes	Engraulidae	*Stolephorus indicus*	DD		No
Clupeiformes	Engraulidae	*Stolephorus insularis*	DD		No
Clupeiformes	Engraulidae	*Thryssa baelama*	DD		No
Clupeiformes	Engraulidae	*Thryssa dussumieri*	DD		No
Clupeiformes	Engraulidae	*Thryssa hamiltonii*	LC		No
Clupeiformes	Engraulidae	*Thryssa vitrirostris*	LC		No
Clupeiformes	Engraulidae	*Thryssa whiteheadi*	LC		Yes
Clupeiformes	Pristigasteridae	*Ilisha compressa*	LC		Yes
Clupeiformes	Pristigasteridae	*Ilisha megaloptera*	DD		No
Clupeiformes	Pristigasteridae	*Ilisha melastoma*	LC		No
Elopiformes	Megalopidae	*Megalops cyprinoides*	DD		No
Gadiformes	Bregmacerotidae	*Bregmaceros arabicus*	DD		No
Gasterosteiformes	Pegasidae	*Pegasus volitans*	LC		No
Gonorynchiforme s	Chanidae	*Chanos chanos*	LC		No
Lophiiformes	Antennariidae	*Antennatus nummifer*	LC		No
Mugiliformes	Mugilidae	*Chelon subviridis*	LC		No
Mugiliformes	Mugilidae	*Liza abu*	LC		No
Mugiliformes	Mugilidae	*Liza carinata*	DD		No
Mugiliformes	Mugilidae	*Liza klunzingeri*	VU	A2bd	No
Mugiliformes	Mugilidae	*Liza persicus*	DD		Yes
Mugiliformes	Mugilidae	*Moolgarda seheli*	LC		No
Mugiliformes	Mugilidae	*Mugil cephalus*	DD		No
Ophidiiformes	Ophidiidae	*Brotula multibarbata*	LC		No

Order	Family	Species	IUCN Red List Category	IUCN Red List Criteria*	Endemic to the Gulf
Ophidiiformes	Ophidiidae	*Neobythites steatiticus*	LC		No
Perciformes	Acanthuridae	*Acanthurus sohal*	VU	B2ab(i,ii,iii)	No
Perciformes	Acanthuridae	*Zebrasoma xanthurum*	VU	B2ab(i,ii,iii)	No
Perciformes	Apogonidae	*Apogon coccineus*	LC		No
Perciformes	Apogonidae	*Apogonichthyoides pharaonis*	LC		No
Perciformes	Apogonidae	*Apogonichthyoides pseudotaeniatus*	LC		No
Perciformes	Apogonidae	*Apogonichthyoides taeniatus*	LC		No
Perciformes	Apogonidae	*Cheilodipterus macrodon*	LC		No
Perciformes	Apogonidae	*Cheilodipterus novemstriatus*	LC		No
Perciformes	Apogonidae	*Cheilodipterus persicus*	LC		No
Perciformes	Apogonidae	*Fowleria vaiulae*	LC		No
Perciformes	Apogonidae	*Fowleria variegata*	LC		No
Perciformes	Apogonidae	*Jaydia queketti*	LC		No
Perciformes	Apogonidae	*Jaydia truncatus*	LC		No
Perciformes	Apogonidae	*Ostorhinchus cookii*	DD		No
Perciformes	Apogonidae	*Ostorhinchus cyanosoma*	LC		No
Perciformes	Apogonidae	*Ostorhinchus fasciatus*	LC		No
Perciformes	Apogonidae	*Ostorhinchus fleurieu*	LC		No
Perciformes	Apogonidae	*Ostorhinchus gularis*	LC		No
Perciformes	Apogonidae	*Pseudamia tarri*	LC		No
Perciformes	Apogonidae	*Taeniamia fucata*	LC		No
Perciformes	Ariommatidae	*Ariomma indicum*	LC		No
Perciformes	Blenniidae	*Alticus kirkii*	VU	D2	No
Perciformes	Blenniidae	*Antennablennius adenensis*	LC		No
Perciformes	Blenniidae	*Antennablennius simonyi*	DD		No
Perciformes	Blenniidae	*Antennablennius variopunctatus*	LC		No
Perciformes	Blenniidae	*Cirripectes filamentosus*	LC		No
Perciformes	Blenniidae	*Ecsenius pulcher*	LC		No
Perciformes	Blenniidae	*Hirculops cornifer*	DD		No
Perciformes	Blenniidae	*Istiblennius pox*	LC		No
Perciformes	Blenniidae	*Mimoblennius cirrosus*	LC		No
Perciformes	Blenniidae	*Omobranchus fasciolatus*	LC		No
Perciformes	Blenniidae	*Omobranchus mekranensis*	VU	D2	No
Perciformes	Blenniidae	*Omobranchus punctatus*	LC		No
Perciformes	Blenniidae	*Parablennius opercularis*	LC		No
Perciformes	Blenniidae	*Petroscirtes ancylodon*	LC		No

Order	Family	Species	IUCN Red List Category	IUCN Red List Criteria*	Endemic to the Gulf
Perciformes	Blenniidae	*Petroscirtes mitratus*	LC		No
Perciformes	Blenniidae	*Xiphasia setifer*	LC		No
Perciformes	Caesionidae	*Caesio lunaris*	VU	B2ab(i,ii,iii)	No
Perciformes	Caesionidae	*Caesio varilineata*	VU	B2ab(i,ii,iii)	No
Perciformes	Callionymidae	*Callionymus erythraeus*	LC		No
Perciformes	Callionymidae	*Callionymus filamentosus*	LC		No
Perciformes	Callionymidae	*Callionymus hindsii*	LC		No
Perciformes	Callionymidae	*Callionymus marleyi*	LC		No
Perciformes	Callionymidae	*Callionymus persicus*	LC		No
Perciformes	Callionymidae	*Callionymus sagitta*	DD		No
Perciformes	Callionymidae	*Diplogrammus pygmaeus*	LC		No
Perciformes	Carangidae	*Alectis ciliaris*	LC		No
Perciformes	Carangidae	*Alectis indica*	LC		No
Perciformes	Carangidae	*Alepes djedaba*	LC		No
Perciformes	Carangidae	*Alepes kleinii*	LC		No
Perciformes	Carangidae	*Alepes melanoptera*	LC		No
Perciformes	Carangidae	*Alepes vari*	LC		No
Perciformes	Carangidae	*Atropus atropos*	LC		No
Perciformes	Carangidae	*Atule mate*	LC		No
Perciformes	Carangidae	*Carangoides bajad*	LC		No
Perciformes	Carangidae	*Carangoides chrysophrys*	LC		No
Perciformes	Carangidae	*Carangoides coeruleopinnatus*	DD		No
Perciformes	Carangidae	*Carangoides ferdau*	LC		No
Perciformes	Carangidae	*Carangoides fulvoguttatus*	LC		No
Perciformes	Carangidae	*Carangoides gymnostethus*	DD		No
Perciformes	Carangidae	*Carangoides malabaricus*	LC		No
Perciformes	Carangidae	*Carangoides praeustus*	LC		No
Perciformes	Carangidae	*Caranx heberi*	LC		No
Perciformes	Carangidae	*Caranx ignobilis*	LC		No
Perciformes	Carangidae	*Caranx sexfasciatus*	LC		No
Perciformes	Carangidae	*Decapterus russelli*	LC		No
Perciformes	Carangidae	*Gnathanodon speciosus*	LC		No
Perciformes	Carangidae	*Megalaspis cordyla*	LC		No
Perciformes	Carangidae	*Naucrates ductor*	LC		No
Perciformes	Carangidae	*Parastromateus niger*	LC		No
Perciformes	Carangidae	*Scomberoides commersonnianus*	LC		No
Perciformes	Carangidae	*Scomberoides lysan*	LC		No

Order	Family	Species	IUCN Red List Category	IUCN Red List Criteria*	Endemic to the Gulf
Perciformes	Carangidae	*Scomberoides tol*	DD		No
Perciformes	Carangidae	*Selar crumenophthalmus*	LC		No
Perciformes	Carangidae	*Selaroides leptolepis*	LC		No
Perciformes	Carangidae	*Seriola dumerili*	LC		No
Perciformes	Carangidae	*Seriolina nigrofasciata*	LC		No
Perciformes	Carangidae	*Trachinotus baillonii*	LC		No
Perciformes	Carangidae	*Trachinotus blochii*	LC		No
Perciformes	Carangidae	*Trachinotus mookalee*	LC		No
Perciformes	Carangidae	*Trachurus indicus*	LC		No
Perciformes	Carangidae	*Ulua mentalis*	LC		No
Perciformes	Carangidae	*Uraspis helvola*	LC		No
Perciformes	Cepolidae	*Acanthocepola abbreviata*	LC		No
Perciformes	Chaetodontidae	*Chaetodon melapterus*	VU	B2ab(i,ii,iii)	No
Perciformes	Chaetodontidae	*Chaetodon nigropunctatus*	VU	B2ab(i,ii,iii)	No
Perciformes	Chaetodontidae	*Heniochus acuminatus*	VU	B2ab(i,ii,iii)	No
Perciformes	Drepaneidae	*Drepane longimana*	LC		No
Perciformes	Drepaneidae	*Drepane punctata*	LC		No
Perciformes	Echeneidae	*Echeneis naucrates*	LC		No
Perciformes	Ephippidae	*Ephippus orbis*	LC		No
Perciformes	Ephippidae	*Platax orbicularis*	LC		No
Perciformes	Ephippidae	*Platax teira*	LC		No
Perciformes	Epinephelidae	*Aethaloperca rogaa*	LC		No
Perciformes	Epinephelidae	*Anyperodon leucogrammicus*	DD		No
Perciformes	Epinephelidae	*Cephalopholis hemistiktos*	NT		No
Perciformes	Epinephelidae	*Epinephelus areolatus*	NT		No
Perciformes	Epinephelidae	*Epinephelus bleekeri*	NT		No
Perciformes	Epinephelidae	*Epinephelus coeruleopunctatus*	LC		No
Perciformes	Epinephelidae	*Epinephelus coioides*	VU	A2d	No
Perciformes	Epinephelidae	*Epinephelus epistictus*	DD		No
Perciformes	Epinephelidae	*Epinephelus latifasciatus*	LC		No
Perciformes	Epinephelidae	*Epinephelus multinotatus*	LC		No
Perciformes	Epinephelidae	*Epinephelus polylepis*	NT		No
Perciformes	Epinephelidae	*Hyporthodus octofasciatus*	DD		No
Perciformes	Gerreidae	*Gerres filamentosus*	LC		No
Perciformes	Gerreidae	*Gerres longirostris*	LC		No
Perciformes	Gerreidae	*Gerres oyena*	LC		No

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Perciformes	Gerreidae	*Pentaprion longimanus*	LC		No
Perciformes	Gobiidae	*Acentrogobius dayi*	DD		No
Perciformes	Gobiidae	*Amblyeleotris diagonalis*	LC		No
Perciformes	Gobiidae	*Amblyeleotris downingi*	LC		No
Perciformes	Gobiidae	*Amblyeleotris periophthalma*	LC		No
Perciformes	Gobiidae	*Amblyeleotris steinitzi*	LC		No
Perciformes	Gobiidae	*Amblyeleotris triguttata*	LC		No
Perciformes	Gobiidae	*Amblygobius albimaculatus*	LC		No
Perciformes	Gobiidae	*Amblygobius nocturnus*	LC		No
Perciformes	Gobiidae	*Asterropteryx semipunctata*	LC		No
Perciformes	Gobiidae	*Aulopareia unicolor*	DD		No
Perciformes	Gobiidae	*Bathygobius fuscus*	LC		No
Perciformes	Gobiidae	*Bathygobius meggitti*	LC		No
Perciformes	Gobiidae	*Boleophthalmus dussumieri*	LC		No
Perciformes	Gobiidae	*Bryaninops amplus*	DD		No
Perciformes	Gobiidae	*Callogobius bifasciatus*	LC		No
Perciformes	Gobiidae	*Callogobius plumatus*	LC		No
Perciformes	Gobiidae	*Coryogalops adamsoni*	LC		No
Perciformes	Gobiidae	*Coryogalops anomolus*	LC		No
Perciformes	Gobiidae	*Coryogalops monospilus*	DD		Yes
Perciformes	Gobiidae	*Coryogalops tessellatus*	LC		No
Perciformes	Gobiidae	*Cryptocentroides arabicus*	LC		No
Perciformes	Gobiidae	*Cryptocentrus lutheri*	LC		No
Perciformes	Gobiidae	*Eviota guttata*	LC		No
Perciformes	Gobiidae	*Eviota pardalota*	LC		No
Perciformes	Gobiidae	*Eviota sebreei*	LC		No
Perciformes	Gobiidae	*Favonigobius melanobranchus*	LC		No
Perciformes	Gobiidae	*Fusigobius inframaculatus*	LC		No
Perciformes	Gobiidae	*Gnatholepis anjerensis*	LC		No
Perciformes	Gobiidae	*Gnatholepis caudimaculata*	LC		No
Perciformes	Gobiidae	*Gobiodon citrinus*	EN	B2ab(i,ii,iii)	No
Perciformes	Gobiidae	*Gobiodon reticulatus*	VU	B2ab(i,ii,iii)	No
Perciformes	Gobiidae	*Gobiopsis canalis*	LC		No
Perciformes	Gobiidae	*Istigobius decoratus*	LC		No
Perciformes	Gobiidae	*Istigobius ornatus*	LC		No
Perciformes	Gobiidae	*Myersina filifer*	LC		No
Perciformes	Gobiidae	*Parachaeturichthys polynema*	LC		No

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Perciformes	Gobiidae	*Periophthalmus kalolo*	LC		No
Perciformes	Gobiidae	*Periophthalmus waltoni*	LC		No
Perciformes	Gobiidae	*Priolepis cincta*	LC		No
Perciformes	Gobiidae	*Priolepis randalli*	LC		No
Perciformes	Gobiidae	*Scartelaos tenuis*	LC		No
Perciformes	Gobiidae	*Taenioides kentalleni*	DD		Yes
Perciformes	Gobiidae	*Tomiyamichthys latruncularius*	LC		No
Perciformes	Gobiidae	*Trimma winterbottomi*	LC		No
Perciformes	Gobiidae	*Trypauchen vagina*	LC		No
Perciformes	Gobiidae	*Valenciennea persica*	LC		No
Perciformes	Gobiidae	*Valenciennea sexguttata*	LC		No
Perciformes	Gobiidae	*Vanderhorstia mertensi*	LC		No
Perciformes	Gobiidae	*Yongeichthys nebulosus*	LC		No
Perciformes	Haemulidae	*Diagramma pictum*	NT		No
Perciformes	Haemulidae	*Plectorhinchus gaterinus*	LC		No
Perciformes	Haemulidae	*Plectorhinchus pictus*	NT		No
Perciformes	Haemulidae	*Plectorhinchus sordidus*	LC		No
Perciformes	Haemulidae	*Pomadasys argenteus*	LC		No
Perciformes	Haemulidae	*Pomadasys kaakan*	LC		No
Perciformes	Haemulidae	*Pomadasys maculatus*	LC		No
Perciformes	Haemulidae	*Pomadasys stridens*	LC		No
Perciformes	Istiophoridae	*Istiophorus platypterus*	LC		No
Perciformes	Kyphosidae	*Kyphosus bigibbus*	DD		No
Perciformes	Kyphosidae	*Kyphosus cinerascens*	DD		No
Perciformes	Kyphosidae	*Kyphosus sectatrix*	DD		No
Perciformes	Kyphosidae	*Kyphosus vaigiensis*	DD		No
Perciformes	Labridae	*Cheilinus lunulatus*	LC		No
Perciformes	Labridae	*Chlorurus sordidus*	VU	B2ab(i,ii,iii)	No
Perciformes	Labridae	*Choerodon robustus*	LC		No
Perciformes	Labridae	*Halichoeres leptotaenia*	LC		Yes
Perciformes	Labridae	*Halichoeres marginatus*	VU	B2ab(i,ii,iii)	No
Perciformes	Labridae	*Halichoeres nigrescens*	LC		No
Perciformes	Labridae	*Halichoeres stigmaticus*	LC		No
Perciformes	Labridae	*Iniistius bimaculatus*	LC		No
Perciformes	Labridae	*Labroides dimidiatus*	LC		No
Perciformes	Labridae	*Leptojulis cyanopleura*	LC		No
Perciformes	Labridae	*Paracheilinus mccoskeri*	LC		No

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Perciformes	Labridae	*Pteragogus flagellifer*	LC		No
Perciformes	Labridae	*Scarus ferrugineus*	VU	B2ab(i,ii,iii)	No
Perciformes	Labridae	*Scarus fuscopurpureus*	DD		No
Perciformes	Labridae	*Scarus ghobban*	EN	B2ab(i,ii,iii)	No
Perciformes	Labridae	*Scarus persicus*	VU	B2ab(i,ii,iii)	No
Perciformes	Labridae	*Scarus psittacus*	DD		No
Perciformes	Labridae	*Stethojulis interrupta*	LC		No
Perciformes	Labridae	*Suezichthys caudavittatus*	LC		No
Perciformes	Labridae	*Thalassoma lunare*	LC		No
Perciformes	Lactariidae	*Lactarius lactarius*	DD		No
Perciformes	Leiognathidae	*Aurigequula fasciata*	DD		No
Perciformes	Leiognathidae	*Deveximentum insidiator*	DD		No
Perciformes	Leiognathidae	*Leiognathus equula*	DD		No
Perciformes	Leiognathidae	*Leiognathus oblongus*	DD		No
Perciformes	Leiognathidae	*Nuchequula gerreoides*	DD		No
Perciformes	Leiognathidae	*Photopectoralis bindus*	DD		No
Perciformes	Lethrinidae	*Lethrinus borbonicus*	LC		No
Perciformes	Lethrinidae	*Lethrinus lentjan*	LC		No
Perciformes	Lethrinidae	*Lethrinus microdon*	LC		No
Perciformes	Lethrinidae	*Lethrinus nebulosus*	LC		No
Perciformes	Lobotidae	*Lobotes surinamensis*	DD		No
Perciformes	Lutjanidae	*Lutjanus argentimaculatus*	LC		No
Perciformes	Lutjanidae	*Lutjanus ehrenbergii*	LC		No
Perciformes	Lutjanidae	*Lutjanus fulviflamma*	LC		No
Perciformes	Lutjanidae	*Lutjanus indicus*	LC		No
Perciformes	Lutjanidae	*Lutjanus johnii*	LC		No
Perciformes	Lutjanidae	*Lutjanus lutjanus*	LC		No
Perciformes	Lutjanidae	*Lutjanus malabaricus*	NT		No
Perciformes	Lutjanidae	*Lutjanus quinquelineatus*	LC		No
Perciformes	Lutjanidae	*Pinjalo pinjalo*	LC		No
Perciformes	Microdesmidae	*Gunnellichthys viridescens*	LC		No
Perciformes	Microdesmidae	*Ptereleotris arabica*	LC		No
Perciformes	Microdesmidae	*Ptereleotris microlepis*	LC		No
Perciformes	Monodactylidae	*Monodactylus argenteus*	DD		No
Perciformes	Mullidae	*Mulloidichthys flavolineatus*	DD		No
Perciformes	Mullidae	*Parupeneus heptacanthus*	LC		No

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Perciformes	Mullidae	*Parupeneus macronemus*	DD		No
Perciformes	Mullidae	*Parupeneus margaritatus*	LC		No
Perciformes	Mullidae	*Upeneus doriae*	LC		No
Perciformes	Mullidae	*Upeneus oligospilus*	LC		Yes
Perciformes	Mullidae	*Upeneus randalli*	DD		Yes
Perciformes	Mullidae	*Upeneus sulphureus*	LC		No
Perciformes	Mullidae	*Upeneus sundaicus*	DD		No
Perciformes	Mullidae	*Upeneus vittatus*	DD		No
Perciformes	Nemipteridae	*Nemipterus bipunctatus*	LC		No
Perciformes	Nemipteridae	*Nemipterus japonicus*	LC		No
Perciformes	Nemipteridae	*Nemipterus peronii*	LC		No
Perciformes	Nemipteridae	*Nemipterus randalli*	LC		No
Perciformes	Nemipteridae	*Parascolopsis aspinosa*	LC		No
Perciformes	Nemipteridae	*Parascolopsis eriomma*	LC		No
Perciformes	Nemipteridae	*Scolopsis bimaculata*	LC		No
Perciformes	Nemipteridae	*Scolopsis ghanam*	LC		No
Perciformes	Nemipteridae	*Scolopsis taeniata*	LC		No
Perciformes	Opistognathidae	*Opistognathus muscatensis*	DD		No
Perciformes	Opistognathidae	*Opistognathus nigromarginatus*	LC		No
Perciformes	Pentacerotidae	*Histiopterus typus*	DD		No
Perciformes	Pinguipedidae	*Parapercis alboguttata*	LC		No
Perciformes	Pinguipedidae	*Parapercis robinsoni*	LC		No
Perciformes	Polynemidae	*Eleutheronema tetradactylum*	EN	A4d	No
Perciformes	Polynemidae	*Polydactylus persicus*	LC		Yes
Perciformes	Pomacanthidae	*Pomacanthus maculosus*	LC		No
Perciformes	Pomacentridae	*Abudefduf vaigiensis*	VU	B2ab(i,ii,iii)	No
Perciformes	Pomacentridae	*Amphiprion clarkii*	EN	B2ab(i,ii,iii)	No
Perciformes	Pomacentridae	*Chromis flavaxilla*	VU	B2ab(i,ii,iii)	No
Perciformes	Pomacentridae	*Chromis xanthopterygia*	EN	B2ab(i,ii,iii)	No
Perciformes	Pomacentridae	*Dascyllus trimaculatus*	VU	B2ab(i,ii,iii)	No
Perciformes	Pomacentridae	*Neopomacentrus cyanomos*	VU	B2ab(i,ii,iii)	No
Perciformes	Pomacentridae	*Neopomacentrus sindensis*	LC		No
Perciformes	Pomacentridae	*Pomacentrus aquilus*	EN	B2ab(i,ii,iii)	No

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Perciformes	Pomacentridae	*Pomacentrus leptus*	EN	B2ab(i,ii,iii)	No
Perciformes	Pomacentridae	*Pomacentrus trichourus*	EN	B2ab(i,ii,iii)	No
Perciformes	Pomacentridae	*Pristotis obtusirostris*	LC		No
Perciformes	Priacanthidae	*Priacanthus hamrur*	LC		No
Perciformes	Priacanthidae	*Priacanthus tayenus*	LC		No
Perciformes	Pseudochromidae	*Pseudochromis aldabraensis*	LC		No
Perciformes	Pseudochromidae	*Pseudochromis linda*	LC		No
Perciformes	Pseudochromidae	*Pseudochromis nigrovittatus*	LC		No
Perciformes	Pseudochromidae	*Pseudochromis persicus*	LC		No
Perciformes	Rachycentridae	*Rachycentron canadum*	LC		No
Perciformes	Scatophagidae	*Scatophagus argus*	LC		No
Perciformes	Sciaenidae	*Argyrosomus amoyensis*	DD		No
Perciformes	Sciaenidae	*Johnius belangerii*	LC		No
Perciformes	Sciaenidae	*Johnius borneensis*	LC		No
Perciformes	Sciaenidae	*Johnius carutta*	DD		No
Perciformes	Sciaenidae	*Johnius sina*	DD		No
Perciformes	Sciaenidae	*Otolithes ruber*	VU	A2ad	No
Perciformes	Sciaenidae	*Pennahia anea*	LC		No
Perciformes	Sciaenidae	*Protonibea diacanthus*	LC		No
Perciformes	Scombridae	*Auxis thazard*	LC		No
Perciformes	Scombridae	*Euthynnus affinis*	LC		No
Perciformes	Scombridae	*Rastrelliger kanagurta*	LC		No
Perciformes	Scombridae	*Scomberomorus commerson*	VU	A2bd	No
Perciformes	Scombridae	*Scomberomorus guttatus*	LC		No
Perciformes	Scombridae	*Thunnus tonggol*	LC		No
Perciformes	Serranidae	*Pseudanthias townsendi*	LC		No
Perciformes	Siganidae	*Siganus canaliculatus*	LC		No
Perciformes	Siganidae	*Siganus javus*	DD		No
Perciformes	Siganidae	*Siganus luridus*	DD		No
Perciformes	Siganidae	*Siganus rivulatus*	DD		No
Perciformes	Sillaginidae	*Sillago arabica*	LC		Yes
Perciformes	Sillaginidae	*Sillago attenuata*	LC		Yes
Perciformes	Sillaginidae	*Sillago sihama*	LC		No
Perciformes	Sparidae	*Acanthopagrus arabicus*	LC		No
Perciformes	Sparidae	*Acanthopagrus bifasciatus*	LC		No
Perciformes	Sparidae	*Acanthopagrus randalli*	DD		No
Perciformes	Sparidae	*Acanthopagrus sheim*	LC		No

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Perciformes	Sparidae	*Argyrops spinifer*	LC		No
Perciformes	Sparidae	*Cheimerius nufar*	LC		No
Perciformes	Sparidae	*Crenidens indicus*	LC		No
Perciformes	Sparidae	*Diplodus sargus*	LC		No
Perciformes	Sparidae	*Pagellus affinis*	LC		No
Perciformes	Sparidae	*Rhabdosargus haffara*	NT		No
Perciformes	Sparidae	*Rhabdosargus sarba*	NT		No
Perciformes	Sparidae	*Sparidentex belayewi*	DD		No
Perciformes	Sparidae	*Sparidentex hasta*	LC		No
Perciformes	Sphyraenidae	*Sphyraena barracuda*	LC		No
Perciformes	Sphyraenidae	*Sphyraena flavicauda*	LC		No
Perciformes	Sphyraenidae	*Sphyraena forsteri*	LC		No
Perciformes	Sphyraenidae	*Sphyraena jello*	LC		No
Perciformes	Sphyraenidae	*Sphyraena obtusata*	LC		No
Perciformes	Sphyraenidae	*Sphyraena putnamae*	LC		No
Perciformes	Sphyraenidae	*Sphyraena qenie*	LC		No
Perciformes	Stromateidae	*Pampus argenteus*	VU	A2d	No
Perciformes	Terapontidae	*Pelates quadrilineatus*	LC		No
Perciformes	Terapontidae	*Terapon jarbua*	LC		No
Perciformes	Terapontidae	*Terapon puta*	LC		No
Perciformes	Terapontidae	*Terapon theraps*	LC		No
Perciformes	Trichiuridae	*Eupleurogrammus glossodon*	LC		No
Perciformes	Trichiuridae	*Eupleurogrammus muticus*	DD		No
Perciformes	Trichiuridae	*Trichiurus lepturus*	LC		No
Perciformes	Trichonotidae	*Trichonotus arabicus*	LC		No
Perciformes	Tripterygiidae	*Enneapterygius pusillus*	LC		No
Perciformes	Tripterygiidae	*Enneapterygius ventermaculus*	LC		No
Perciformes	Tripterygiidae	*Helcogramma steinitzi*	LC		No
Perciformes	Uranoscopidae	*Uranoscopus dollfusi*	LC		No
Perciformes	Uranoscopidae	*Uranoscopus guttatus*	DD		No
Perciformes	Xenisthmidae	*Xenisthmus balius*	LC		Yes
Pleuronectiformes	Bothidae	*Arnoglossus aspilos*	LC		No
Pleuronectiformes	Bothidae	*Arnoglossus macrolophus*	LC		No
Pleuronectiformes	Bothidae	*Bothus pantherinus*	LC		No
Pleuronectiformes	Bothidae	*Grammatobothus polyophthalmus*	DD		No
Pleuronectiformes	Bothidae	*Laeops guentheri*	DD		No
Pleuronectiformes	Citharidae	*Brachypleura novaezeelandiae*	LC		No
Pleuronectiformes	Cynoglossidae	*Cynoglossus arel*	LC		No

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Pleuronectiformes	Cynoglossidae	*Cynoglossus kopsii*	DD		No
Pleuronectiformes	Cynoglossidae	*Cynoglossus puncticeps*	DD		No
Pleuronectiformes	Cynoglossidae	*Cynoglossus quadrilineatus*	LC		No
Pleuronectiformes	Paralichthyidae	*Pseudorhombus arsius*	LC		No
Pleuronectiformes	Paralichthyidae	*Pseudorhombus elevatus*	LC		No
Pleuronectiformes	Paralichthyidae	*Pseudorhombus javanicus*	LC		No
Pleuronectiformes	Paralichthyidae	*Pseudorhombus malayanus*	LC		No
Pleuronectiformes	Psettodidae	*Psettodes erumei*	DD		No
Pleuronectiformes	Soleidae	*Aesopia cornuta*	DD		No
Pleuronectiformes	Soleidae	*Brachirus orientalis*	LC		No
Pleuronectiformes	Soleidae	*Pardachirus marmoratus*	LC		No
Pleuronectiformes	Soleidae	*Solea elongata*	LC		No
Pleuronectiformes	Soleidae	*Solea stanalandi*	DD		Yes
Pleuronectiformes	Soleidae	*Zebrias captivus*	DD		Yes
Pleuronectiformes	Soleidae	*Zebrias synapturoides*	DD		No
Scorpaeniformes	Apistidae	*Apistus carinatus*	LC		No
Scorpaeniformes	Dactylopteridae	*Dactyloptena gilberti*	LC		No
Scorpaeniformes	Dactylopteridae	*Dactyloptena orientalis*	LC		No
Scorpaeniformes	Platycephalidae	*Grammoplites suppositus*	LC		No
Scorpaeniformes	Platycephalidae	*Grammoplites vittatus*	DD		No
Scorpaeniformes	Platycephalidae	*Kumococius rodericensis*	LC		No
Scorpaeniformes	Platycephalidae	*Platycephalus indicus*	LC		No
Scorpaeniformes	Platycephalidae	*Rogadius pristiger*	LC		No
Scorpaeniformes	Platycephalidae	*Sorsogona melanoptera*	LC		No
Scorpaeniformes	Platycephalidae	*Sorsogona nigripinna*	DD		No
Scorpaeniformes	Platycephalidae	*Sorsogona prionota*	LC		No
Scorpaeniformes	Platycephalidae	*Sorsogona tuberculata*	LC		No
Scorpaeniformes	Platycephalidae	*Thysanophrys celebica*	LC		No
Scorpaeniformes	Scorpaenidae	*Brachypterois serrulifer*	DD		No
Scorpaeniformes	Scorpaenidae	*Pterois miles*	LC		No
Scorpaeniformes	Scorpaenidae	*Pterois russelii*	LC		No
Scorpaeniformes	Scorpaenidae	*Scorpaenopsis barbata*	LC		No
Scorpaeniformes	Scorpaenidae	*Scorpaenopsis oxycephala*	LC		No
Scorpaeniformes	Scorpaenidae	*Scorpaenopsis venosa*	DD		No
Scorpaeniformes	Synanceiidae	*Choridactylus multibarbus*	LC		No
Scorpaeniformes	Synanceiidae	*Minous dempsterae*	LC		No
Scorpaeniformes	Synanceiidae	*Minous inermis*	DD		No
Scorpaeniformes	Synanceiidae	*Minous monodactylus*	LC		No

Order	Family	Species	IUCN Red List Category	IUCN Red List Criteria*	Endemic to the Gulf
Scorpaeniformes	Synanceiidae	*Pseudosynanceia melanostigma*	DD		No
Scorpaeniformes	Synanceiidae	*Synanceia nana*	LC		No
Scorpaeniformes	Triglidae	*Lepidotrigla bispinosa*	LC		No
Scorpaeniformes	Triglidae	*Lepidotrigla faurei*	LC		No
Siluriformes	Ariidae	*Arius maculatus*	DD		No
Siluriformes	Ariidae	*Netuma bilineata*	LC		No
Siluriformes	Ariidae	*Netuma thalassina*	LC		No
Siluriformes	Ariidae	*Plicofollis dussumieri*	DD		No
Siluriformes	Ariidae	*Plicofollis tenuispinis*	DD		No
Siluriformes	Plotosidae	*Plotosus lineatus*	LC		No
Syngnathiformes	Centriscidae	*Centriscus scutatus*	LC		No
Syngnathiformes	Fistulariidae	*Fistularia petimba*	LC		No
Syngnathiformes	Syngnathidae	*Acentronura tentaculata*	DD		No
Syngnathiformes	Syngnathidae	*Bryx analicarens*	DD		No
Syngnathiformes	Syngnathidae	*Choeroichthys brachysoma*	DD		No
Syngnathiformes	Syngnathidae	*Cosmocampus investigatoris*	LC		No
Syngnathiformes	Syngnathidae	*Doryrhamphus excisus*	DD		No
Syngnathiformes	Syngnathidae	*Hippichthys penicillus*	DD		No
Syngnathiformes	Syngnathidae	*Hippocampus kuda*	DD		No
Syngnathiformes	Syngnathidae	*Trachyrhamphus bicoarctatus*	DD		No
Tetraodontiformes	Balistidae	*Abalistes stellatus*	LC		No
Tetraodontiformes	Balistidae	*Rhinecanthus assasi*	LC		No
Tetraodontiformes	Diodontidae	*Cyclichthys orbicularis*	LC		No
Tetraodontiformes	Monacanthidae	*Aluterus monoceros*	LC		No
Tetraodontiformes	Monacanthidae	*Paramonacanthus arabicus*	DD		Yes
Tetraodontiformes	Monacanthidae	*Paramonacanthus oblongus*	LC		No
Tetraodontiformes	Monacanthidae	*Stephanolepis diaspros*	LC		No
Tetraodontiformes	Ostraciidae	*Ostracion cubicus*	LC		No
Tetraodontiformes	Ostraciidae	*Ostracion cyanurus*	LC		No
Tetraodontiformes	Ostraciidae	*Tetrosomus gibbosus*	LC		No
Tetraodontiformes	Tetraodontidae	*Arothron stellatus*	LC		No
Tetraodontiformes	Tetraodontidae	*Chelonodon patoca*	LC		No
Tetraodontiformes	Tetraodontidae	*Lagocephalus guentheri*	DD		No
Tetraodontiformes	Tetraodontidae	*Lagocephalus lunaris*	LC		No
Tetraodontiformes	Tetraodontidae	*Lagocephalus sceleratus*	LC		No
Tetraodontiformes	Tetraodontidae	*Lagocephalus spadiceus*	LC		No
Tetraodontiformes	Tetraodontidae	*Torquigener flavimaculosus*	LC		No
Tetraodontiformes	Triacanthidae	*Pseudotriacanthus strigilifer*	LC		No

Order	Family	Species	IUCN Red List Category	IUCN Red List Criteria*	Endemic to the Gulf
Tetraodontiformes	Triacanthidae	*Triacanthus biaculeatus*	LC		No

*The IUCN criteria, provided for threatened species (those assessed as VU, EN or CR), describe the specific reasons for why the species qualifies for a threatened status. Additional information on the IUCN Red List categories and criteria can be found in the IUCN Red List Documentation available at: **http://www.iucnredlist.org/technical-documents/red-list-documents**

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EXPERIENCE

Graduate Research Assistant	Old Dominion University	Norfolk, VA	08/2012-05/2016
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PUBLICATIONS AND PRESENTATIONS

- Buchanan, J.R., Krupp, F., Burt, J.A., Feary, D.A., Ralph, G.M., & Carpenter, K.E. 2016. Living on the edge: Vulnerability of coral-dependent fishes in the Gulf. Marine Pollution Bulletin 105:480-488. DOI:10.1016/j.marpolbul.2015.11.033

- Buchanan, J.R., Krupp, F., Burt, J.A., Feary, D.A., Ralph, G.M., & Carpenter, K.E. (June 2016). Living on the edge: Regional extinction risk of coral-dependent fishes in a marginal Gulf. Poster Presentation, 13th International Coral Reef Symposium, Honolulu, HI, USA

- Buchanan, J.R., Carpenter, K.E., Krupp, F., Al-Muftah, A., & Ralph, G.M. (March 2015). Conservation status of the marine bony fishes in the Arabian Gulf. Oral Presentation, Old Dominion University Biology Graduate Student Organization 2015 Spring Symposium, Norfolk, VA, USA

- Buchanan, J.R., Carpenter, K.E., Krupp, F., Al-Muftah, A., & Ralph, G.M. (February 2015). Conservation status of the coral reef fishes in the Gulf. Oral Presentation, Coral Reefs of Arabia, Abu Dhabi, United Arab Emirates

- Buchanan, J.R. (February 2014). IUCN Red List Categories and Criteria. Oral Presentation, IUCN Red List Assessment Workshop, Doha, Qatar

- Buchanan, J.R. (October 2013). Using the IUCN Red List Criteria at Regional Levels. Oral Presentation, IUCN Red List Training Workshop, Doha, Qatar